AGRICULTURAL EDUCATION IN THE UNITED STATES

BY

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"How can he get wisdom that holdeth the plough, and that glorieth in the goad, that driveth oxen and is occupied in their labours, and whose talk is of bullocks?"

PREFACE

It is ill-advised, in a way, to let this report on agricultural education in the United States pass into the publisher's hands. For it was written by a man who knows very little about education and nothing at all about practical agriculture. But Doctor Wickliffe Rose of the General Education Board, who engaged him to make it, had the somewhat unconventional idea that a layman, without professional training and without institutional loyalties, might produce some useful ideas.

The layman, of course, put himself at once on the mercy of those who knew something about the subject, people like Dean Mann of Cornell, C. B. Hutchison, now Director of the Giannini Foundation of the University of California, L. R. Jones and L. J. Cole of the University of Wisconsin, Gortner and Stakman of Minnesota. Doctors East and Bailey of the Bussey Institution, Livingston of Johns Hopkins, Osborne and Mendel of Yale, put their valuable time at his disposal while he asked a lot of elementary questions. Out of these talks, out of a considerable amount of reading, out of visits to some twenty-five agricultural institutions in various parts of the country, this study eventually emerged.

The report was made, in the first instance, for the

officers and trustees of the General Education Board, in the hope that it might provide some suggestions as to the more important needs of agricultural education, and the way in which foundation funds might help to meet them. But before it was submitted, some of the men who had already given generously of their time, agreed to read and criticize it. They then asked that when it had served its first purpose it might be printed: and the officers of the General Education Board have herewith allowed their wishes to be met.

But it is, after all, an irresponsible publication. The General Education Board does not endorse its substance: the several patient and friendly people who contributed their experienced knowledge cannot be held responsible for its views: and the author himself, after a strange and stimulating interlude, is back in business again. So the book must stand on its own feet: first, as a record of the way an outsider, living in the middle of New York City, had his eyes well opened to the importance, the problems and the personnel of one great educational field: second, as a sympathetic but candid criticism of some of the trends of agricultural education to-day: third, as an effort to contribute to its advancement, and thereby, in a small degree, to the social and economic advancement of the United States.

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New York City.

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AGRICULTURAL EDUCATION IN THE UNITED STATES

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CHAPTER I

THE NATION AND ITS AGRICULTURE

This is a lay study of one aspect of education in the United States. It will contain a general review of certain agricultural institutions—their history, scope, objectives, personnel, curricula, the needs they fill and the work they do. The fact that the author has had no professional experience in the field may account for much. It may explain why he finds himself looking at these institutions as intellectual centers rather than as practical agencies; why more stress has been laid upon education than upon agriculture. Then too, other people, better qualified, have written with the second emphasis, and it is unnecessary to go over their ground again.

1.

In beginning, it might be well to speak about the economic setting—the place which the business of agriculture occupies in the present scheme of national life and policy.

In 1920 half the people of the United States were living in communities of 2,500 or less. This does not mean that the agricultural population was then in the neighborhood of 55,000,000. But when one considers the immediate and visible interdependence of village and near-by farm, it can be fairly said that half the population of the United States in 1920 went to make up the nation's rural community.

The same census also provides a basis for estimating the number of people (including their families) engaged in agriculture. Analyzed by Mitchell and others in their survey of *Income in the United States,* these figures showed that twenty-eight per cent of persons working at gainful pursuits were farmers. Hence the agricultural population of the last census year may be estimated at twenty-eight per cent of 110,000,000 or approximately 30,000,000 people. Their land, buildings, farm machinery and live stock were worth more than eighty billions of dollars, while the annual value of crops and animal products reached a total of between fifteen and twenty billions. Moreover, there are twenty-five million other people whose mode of life is influenced by that of the adjacent countryside, and whose livelihood depends upon the prosperity of their neighbors.

In short, the condition of agriculture is a national concern second to none. Food and raw materials come out of the land: industry and trade depend not only upon the assurance of an adequate supply of these raw materials, but upon the assurance of a

prosperous rural market for finished products.[1] The close relation between city and country, agriculture and industry, farmer and laborer is the economic and social foundation of the state. Sir Horace Plunkett has said it more persuasively: "The well-being of a people is like a tree: agriculture is its root, manufactures and commerce are its branches and its life; if the root is injured, the leaves fall, the branches break away, and the tree dies."

2.

The Country Life Commission published its report in 1910. By that time the farmer had struggled out of his thirty-year economic depression, research and teaching had made themselves felt, state legislatures had increased their grants for these two purposes, and there had been a good deal of informative propaganda. Helped by these factors, the Commis-

[1] "The outstanding feature of these accounts is the decrease in profits from trading and the absence of any final dividend in respect of trade. Let me remind you, then, of what is fundamental to this part of our business. In Canada the trade of the city reflects the condition of the country. Our saleshops depend primarily upon the activities of the farmer, and the farmer depends upon the seasons. By great misfortune, unfavorable weather commenced in September, 1926, just when bright sunshine was required for what had promised to be a really wonderful harvest. . . . The first snows fell thickly on sheaves unthreshed and fields uncut. This long-drawn-out harvest resulted in the farming communities having less money to spend and less opportunity of spending it during the closing months of the year, when we always expect the most trade."

(A report of the Governor and Company of Adventurers of England Trading into Hudson's Bay—June, 1927.)

sion's report stimulated the enrollment of students in agricultural colleges, the development of the fields of agricultural economics, rural sociology and home economics, and the passage of the Smith-Lever Act of 1914.

But for popular understanding, particularly in urban quarters, we must look to the war and post-war periods. Nationwide campaigns to increase production through boys' and girls' clubs, propaganda for the conservation of vegetables and fruit, restrictions upon the use of sugar and white flour, all contributed to a common appreciation of the importance of agriculture in time of war. And this appreciation grew during the period of deflation, 1921-1924, when the farmer was feeling the effect of post-war conditions acutely. Urged during the war by the Government to greater and greater output, lured even out of industrial and professional occupations into the country by the prospect of quick profits, farmers in general and wheat farmers in particular suddenly felt the basis of existence slip from under their feet. Land values declined while taxes rose substantially. The price of commodities which the farmer had for sale dropped to an alarmingly low figure, while the cost of the commodities which he had to buy did not drop in proportion.

In this time of post-war deflation, as in the war period, exceptional circumstances forced the difficulties of the farmer before the country at large, until it is now generally understood that agriculture, even

in normal years and under average conditions, presents a serious problem. And it is important that this issue be considered before the interest aroused by the events of the past ten years dies out.

3.

During the first century and a half of its history, the United States was a rural nation. It was rural in two senses: first, the majority of its population lived in small villages or on farms; second, the trend of its growth depended upon the availability of free land, or land at a nominal price. "The most significant thing about the American frontier," says Turner, "is that it lies at the hither edge of free land." The frontier disappeared about 1890, and in 1920 the population of the United States became predominantly urban for the first time in its history. The following figures from the Census tell the story:

Rural population (i.e. people living either on farms or in villages of 2,500 or less)

1880	70.5 per cent
1890	63.9 per cent
1900	59.5 per cent
1910	53.7 per cent
1920	49.3 per cent

The decline is decisive and represents nothing short of a radical change in the character of the American population. It is not suggested that "something should be done" to stop the downward

trend of these figures.[3] The direct line of attack is worse than useless; it is vicious. People ought to determine, and in the end will determine, where they will live their lives, not because orators, quoting from the "Deserted Village," urge them back to the land, but because there is a decent livelihood there. The fact remains, however, that a smaller proportion of the population than ever before is producing food for the rest.

This fact alone is not disturbing, for under some conditions a smaller proportion might produce more food than greater numbers under other conditions. Indeed this has happened. In 1820, eighty-seven per cent of the people were employed in agricultural production. With each succeeding census the proportion decreased until in 1910 only thirty-three per cent farmed for the nation and raised a large surplus for export as well. From 1890 to about 1906, in spite of the relative decrease in the rural population, there was a marked increase in the average food production per capita of the population to be fed. This was partly due to the opening up of rich virgin lands for cultivation, but more particularly to the introduction of improved machinery and methods. Since 1906, however, there has been little or no virgin land opened up—indeed, there is little

[3] The trend is not peculiar to the United States. The Canadian Royal Commission on Industrial and Technical Education (1917) reported the tendency for urban population to grow faster than rural in every country visited, with the single exception of Denmark. The exception, by the way, is significant.

or none available—and improved methods and machinery have failed to keep pace with the growing population of the country. Viewing crop production as a whole, statisticians estimate that we shall become a food importing rather than a food exporting nation in fifteen to twenty-five years' time. To-day, if one measures by money value, we import more food than we export.

Three general considerations may therefore be set down:

a. A nation, formerly rural, is now becoming urban. This is a fact; it may prove to be a calamity.[8]

b. Food production is not keeping pace with population growth. This is a national concern: it may introduce international complications.

c. The United States may have to turn its eyes more towards Canada, South America, and Siberia as sources of food supply, with all the changes that such a new outlook would involve.

Such questions, however, are related not to education but to statecraft. They are perhaps the ultimate questions: and they require wise meditation. "Neither in the new world," says George Russell (Æ), "nor the old has there been much first-class thinking on the life of the countryman. This will be apparent if we consider the quality of thought which

[8] Or not. Opinions differ. J. B. S. Haldane writes in *Daedalus*, "I do not regret the probable disappearance of the agricultural laborer in favor of the factory worker, who seems to me a higher type of person from most points of view. Human progress in historical time has been the progress of cities dragging a reluctant countryside in their wake."

has been devoted to the problems of the City State or the constitution of widespread dominions, from the days of Solon and Aristotle down to the time of Alexander Hamilton, and compare it with the quality of thought which has been brought to bear on the problems of the rural community." As far as this survey is concerned, these issues will have to be left on one side: but it is not too much to hope that some day men and women, trained in agricultural institutions, will play a decisive part in their solution.

CHAPTER II

THE SYSTEM OF AGRICULTURAL EDUCATION

In the following chapters the system of agricultural education in the United States will be described and the place which the colleges hold in it will be indicated. The history of the colleges will be traced, together with that of other agricultural *institutions of junior grade and of different purpose.* The function of the colleges to-day and to-morrow, the way they are fulfilling it and the means at their disposal will then be considered. Finally, some suggestions will be put forward regarding possible developments.

1.

Agricultural education is advanced in many ways. The general village store provides one, the Boyce Thompson Institute for Plant Research provides another. A country banker convinces his client that he is asking for an unwarrantably large loan to finance an unwarrantably big cotton acreage; the Carnegie Laboratory in Arizona prints a paper on the chemistry of photosynthesis; the President of the United States explains why he has vetoed the

McNary-Haugen Bill; someone talks on alfalfa at the local grange. The little red schoolhouse, or its present-day counterpart, plays a considerable rôle, for it gives regular instruction to children who live deep in the country. The consolidated rural school, better built, equipped, and staffed, serves the same end. Indeed, any number of people, agencies, and institutions contribute to agricultural education if the word be used in its widest sense.

But there are, in every state of the Union, institutions which embrace resident teaching, research, and extension. Their chief interest is in the art of agriculture or in the sciences which lie at the root of sound practice, and they are concerned about the intelligence and standards of people who live on the land. Such institutions, of both secondary and collegiate grade, are said to form a system. They form a system, if you please, because they exist by virtue of certain principles. One principle is that agriculture can be advanced for the State and for the individual by schools and colleges which are definitely designed to advance it. This belief was widely held when the first institutions were set up in the United States: their growth since that time, more especially during the last generation, seems to confirm its essential soundness.

In the second place, they are all tax supported.[4]

[4] That is, in the "system"; though one can find agricultural work at Columbia, Syracuse, Berea, St. Lawrence—in fact in about fifteen private institutions. (See RUS Edition, 1925.)

They are part of the scheme of public education in a democracy—the State's fulfillment of an obligation to facilitate education for its citizens. Ideally, this education should be as good as possible, for as many people as possible, at as little cost as possible; and it can be confidently said that progress is being made toward that goal.

Thirdly, these institutions are bound together by a feeling that they must make some tangible return to the State over and above that of providing the best possible education for their students. Just how they fulfill that obligation depends, of course, upon the locality and the nature of the near-by need. It varies, in degree, *among institutions* of the same level, and, in kind, among institutions of different grades. But the sense of public duty is always there. If it is a school, the school feels an obligation to become the stimulating center of community life. If it is a college, the college is directed toward specific public ends; its teaching is for the sake of training better farmers or agricultural leaders, its research is to improve the economic condition of the state and the nation, and its extension work is to better the circumstances of rural life. Students are required to take courses in military science, while history, economics and "civics" are taught to promote good citizenship. One can only generalize broadly; but with that qualification it is true to say that the interests of the external State occupy a far more important place in the program of public

institutions than they do in the conception and conduct of private schools and colleges.

2.

But when the word "system" is used, something more than a collection is meant, even though the units which make it up have certain important elements in common. One knows, instinctively, that the private schools and colleges do not form a system. They are essentially independent of each other as the agricultural institutions are essentially interdependent. They lack the element of organization which the agricultural group (for better or worse) possesses.

As for most of the schools which teach agriculture in the various states, they receive part of their funds for this purpose from Washington,—through state channels to be sure, but in the last analysis from Washington. Their principals meet locally, sectionally, nationally from time to time with encouragement from the Federal Board for Vocational Education. In the case of the colleges, the common bond is stronger and more ancient. The Federal legislation which brought them into existence called for identical contracts with all the state legislatures. Each time Congress has given more money, whether for teaching, research, or extension, another nebulous relationship with some department of government has arisen. The college authorities make annual reports to the Department of the Interior

which show how they have invested and spent the income they derive from the Acts of 1862, 1890, and 1907; they account to the Department of Agriculture—in no particularly bothersome way, but nevertheless, they do account each year for expenditures under the national research appropriations of 1887, 1906, and 1925. What is more, the major part of the research undertaken in the various states is now on a project basis, and the Department of Agriculture has a measurable degree of supervision of these projects, looking toward a "well-coördinated system of agricultural experimentation from the national point of view." Even closer connection with the Department exists under the Smith-Lever Extension Act of 1914. "Each state submits to the Secretary of Agriculture plans of work for the ensuing year. After these plans are approved by the Secretary, the state is certified for its share of the Federal appropriations for the next six months." And so, concludes the government specialist, "the Department of Agriculture exercises close supervision over the agricultural research and the agricultural extension work which is conducted by the states aided by the Federal Government."

Together these colleges have shared in the proceeds of Federal funds. To some extent they have coöperated with each other in scientific work on common problems. They have fought together for recognition as institutions of higher learning for more than half a century, and for the past forty-

four years their administrative heads have met under the auspices of their own Association of Land-Grant Colleges to discuss matters of mutual interest. Students from the agricultural schools pass on to the agricultural colleges;[5] the colleges in turn train teachers for the schools. Their research eventually becomes part of the store of science and so eventually takes its place in school instruction. Upon such relationships as these, sometimes explicit, sometimes shadowy, the system of agricultural education in the United States depends.

3.

On the structural side, therefore, agricultural students, starting in the rural school (or sometimes in the city) ascend through Smith-Hughes vocational schools, or certain other high schools, or a few special secondary schools[6] to the colleges and universities with their accompanying experiment stations.

On the functional side, three ends are served:

1. Teaching, through rural elementary schools, Smith-Hughes schools, and a few others of equal grade, colleges and experiment stations;

[5] This statement needs a note of explanation. The ordinary rural school does prepare for the agricultural college, but not exclusively. The newer Smith-Hughes vocational schools do send their graduates to the agricultural college, but in some states (Minnesota for example) there is a tendency to regard the school as a *Realschule* rather than a *Gymnasium*.

[6] As in New York, Wisconsin and Minnesota.

2. Research, through the Department of Agriculture, colleges and experiment stations;
3. Extension, through the colleges and experiment stations (aided by the Department of Agriculture) and represented by
    - Short courses,
    - Teaching visits to the field,
    - Bulletins,
    - County agents,
    - Demonstration farms,
    - Club work, etc.

Viewed in any aspect, the agricultural college and the experiment station are of central importance. There scientific discoveries are made, students are taught, teachers are trained and extension work receives its content. The college with its station is the source of the stream which runs down to the schools and out into the farm: it is the "fountain and spring" of agricultural education. And the story of the college—its beginnings, difficulties, growth and developing nature—throws light upon agricultural education as a whole.

CHAPTER III

THE HISTORY OF THE AGRICULTURAL COLLEGES

1.

1783–1862

On July 2, 1862, the President of the United States signed a bill intended to promote agricultural and industrial education. By its terms, extensive public lands were conditionally granted by the Federal Government to the several states. From the sale of these lands, funds were to be set aside for "the endowment, support, and maintenance of at least one college, where the leading object shall be, without excluding other scientific and classical studies, and including military tactics, to teach such branches of learning as are related to agriculture and the mechanic arts, in such manner as the legislatures of the several states may respectively prescribe, in order to promote the liberal and practical education of the industrial classes in the several pursuits and professions of life." The Act has ever since been popularly called the "Morrill Act of 1862," in honor of the man who sponsored it, and the institutions which grew out of it have been known as the "Land-Grant Colleges."

Attempts have been made to find a better title for this group of institutions, but none have succeeded and the name will probably remain what it is.

A point is sometimes made of the fact that the President who finally approved the bill was Abraham Lincoln, as if, thereby, to add prestige to the colleges; but it does not appear that he had any special interest in the matter. More often, and with perhaps more justification, one is reminded that the measure was passed in the midst of civil war; that in the hour when McClellan's army was in retreat after the bloody battle of Malvern Hill, the Federal Government was setting aside 11,000,000 acres of land to promote the arts and industries of a peace not yet in sight. "Since the Romans quietly bought and sold the lands on which the Carthaginians were encamped in the neighborhood of the Eternal City, there has been no more noble exhibition of faith in the destiny of a republic." So Andrew D. White was once moved to say; but a careful examination of the Congressional debates concerning the bill fails to disclose in the Senate and in the House any such perspective concerning the approach of the enemy's army or the future of the State as President White would have had one think.

If it is more prosaic, it is likewise truer to say that the Act came neither by genius nor suddenly. The movement toward Federal support for agricultural education had been under way for a long time.

Before the end of the eighteenth century, local and state societies for the promotion of agricultural practice had sprung up. A chair of natural history, chemistry, and agriculture had been established at Columbia; the claims of agricultural education had been formally presented to the Pennsylvania legislature; and Washington, in his second annual message, had proposed to the consideration of Congress "the expediency of establishing a national university"; for, as he said, "it will not be doubted that, with reference either to individual or national welfare, agriculture is of primary importance. In proportion as nations advance in population and other circumstances of maturity, this truth becomes more apparent and renders the cultivation of the soil more and more an object of public patronage. Institutions for promoting it grow up supported by the public purse, and to what object can it be dedicated with greater propriety?" This early effort to advance agriculture by instructing the farmer how to practice his art was a reflection of the times. New crops and breeds of animals were being introduced, and the possible applications of chemistry had been intimated by some of Lavoisier's work. What is more, just as one may see it in the new European states to-day, the young republic felt profound stirrings and keen responsibilities. Self-development was following upon self-determination.

For the next two generations, however, the movement made little headway. The Napoleonic War

and the War of 1812 served to check the forward course of the nation's rural progress, for the interruption of commerce forced the United States to develop its own manufactures with rapidity. Young men were drawn in numbers from farms to new industries. In fact, it was not until 1838, when a crop failure upset the favorable trade balance and caused the importation of millions of dollars' worth of breadstuffs, that attention was once more directed to agricultural needs. Societies again became active, secondary schools were established "wherein the elements and scientific principles of agriculture should be taught," Congress made its first appropriation for investigation in this field of economy; and in 1847, in a special report, the Commissioner of Patents published a study of European agricultural education.

At the end of the eighteenth century, attention had been fixed upon "the advancement of agriculture." Societies, schools, fairs, cattle shows, prizes of various sorts, manuals of practice—all had been advocated as useful means to this end. But now, in a generation of material and intellectual expansion, three other powerful elements appeared—the new science, the new education, and the new society. They took hold vigorously at just that moment; their influence, changing somewhat with changing times, still persists. Later in this study the factors of agriculture, science, education, and society will be considered as they relate to the situation in the

Land-Grant Colleges to-day. It is now sufficient to speak briefly of their appearance during the twenty years which preceded the outbreak of the Civil War.

In the history of the world's intellectual activity and material progress the period between 1840 and 1860 has an important place. There was an absorbing interest in steam transportation; railroads and ocean steamships became practicable; iron-working, dyeing, and many other arts were revolutionized by chemistry; commercial fertilizers came into use, and the electric telegraph was invented. Popular works on science were widely read and prepared the public to expect great benefits from its application. Liebig's "Organic Chemistry Applied to Agriculture and Physiology" appeared at the very beginning of this period, and his "Letters on Chemistry" aroused high hopes. Science was spanning time and distance. The horizon of men was widening, their imaginations were quickened, and with this quickening they questioned whether the old education could cope with new needs. Science, they felt, would have to be substituted for much of the Latin and Greek of the existing régime; but exactly what the scientific discipline was to be and what were to be its institutions were matters upon which educational leaders differed widely.

There had been schools for instruction in agricultural and industrial arts for fifty years. But it would be unsound to consider them as precursors of the colleges. For they were secondary trade

schools, planted here and there, where agriculture might be advanced by giving rule-of-thumb instruction to a limited number of youngsters who came from farms and were going back again. There was little or no conception of education through them as education is conceived to-day, and certainly none at all as compared with the formal classical discipline of the conventional American school of 1850. They were specialized, vocational agencies, and they were socially narrowing in the sense that they tended to fix the pupil forever in his station. The youngster, in the scheme of things, was to be tempered into a better tool for the advancement of the agricultural welfare of the nation. Luckily their influence was slight, but the fact of their existence suggested something finer and their great limitations drew attention to greater needs.

As early as 1835 Doctor Lyman Beecher had declared, "So various are the opinions and habits, and so recent and imperfect is the acquaintance, and so sparse are the settlements of the West, that no homogeneous public sentiment can be formed to legislate immediately into being the requisite institutions. And yet they are all needed immediately in their utmost perfection and power. . . . What will become of the West if her prosperity rushes up to such a majesty, while those great institutions linger which are necessary to form the mind and the conscience and the heart of that vast world?" [7]

[7] Quoted by Turner in "The Frontier in American History."

By 1860 new "requisite institutions" had to be formed; and by that time, the West as a political and social force was powerful enough to give them their democratic character. Education thus and then conceived was no longer to spring from the East, from its tradition of the aristocracy of certain professions—law, teaching, the ministry, and medicine—and from the loins of older institutions whose curricula and ideals were shaped with reference to these specialized groups. For by limiting the content of education to subjects intended to prepare men for "high" professions, privileges were conferred, a caste became established in government and social life, and other young men and women outside the caste were handicapped in the struggle for official and social preferment. That régime would no longer suffice. The democratic ideal, furthermore, demanded that the gates of learning be opened to greater numbers, throughout the whole country, and at a lower cost. "All was motion and change, restlessness was universal. Men moved in their single life, from Vermont to New York, from New York to Ohio, from Ohio to Wisconsin, from Wisconsin to California, and longed for the Hawaiian Islands. They were conscious of the mobility of their society and gloried in it. They broke with the Past and thought to create something finer, more fitting for humanity, more beneficial for the average man than the world had ever seen." [8]

[8] Turner, op. cit.

In 1857, in these times of expansion and of confusion, Justin Morrill, then a member of the House of Representatives, first introduced his bill for the establishment of agricultural and mechanical colleges. It passed both Houses in due course, but was vetoed by President Buchanan. The Southern members in both bodies were a strong minority, and their constitutional objections to Federal aid carried great weight with the President. Late in 1861, with a new executive in office, and with all the stubborn Southern members absent at war, Morrill introduced his bill again. By the next June it had passed both Houses, and early in July it became law.

Like all other great national figures, Senator Morrill has had his extreme critics and admirers. Those who speak of his work as "a service which deserves to be ranked, and which future historians will rank, with those of Hamilton in advocating the Constitution, of Jefferson in acquiring Louisiana, and of Clay in giving us a truly American policy," [9] will do well to remember that the man they eulogize was no innovating genius. The Land-Grant Colleges did not spring, like Athene, full-armed from the brain of Zeus: they grew out of experience. A thorough study of European agricultural teaching and research made by a government agent had been twice reprinted with the authorization of Congress. One higher state agricultural institution was authorized

[9] "Justin Smith Morrill," by W. B. Parker, 1924, p. 259. Quoting Andrew D. White.

before the Morrill bill was introduced; three in all had actually been opened before the bill was passed.

But if the Senator was no genius, he was likewise no mere politician. And one must equally strongly dissent from the view that "Senator Morrill himself knew very little of education," that "his wish was 'to do something for the farmer'" and that "his bill took this form, not from any sound educational reason, but as being one of the most likely means by which something could be done for the farmers as a makeweight to the things done for other groups in the body politic."[10] Here is not the place to appraise Morrill's knowledge of education: his claims are all considered in his *Life*. It is enough to say that his library was large and well read; his correspondence with Gilman of Johns Hopkins, White of Cornell, and Buckham of Vermont shows complete fellowship with the company of scholars; and his refusal to serve upon the Board of Trustees of Norwich University on the ground that the University was sacrificing its reputation for scholarship by granting honorary degrees without sufficient discrimination, gives evidence of standards and courage which might well be wept for to-day. Nor was he a politician in the critical sense of the word. "It took five years to make the bill a law, but he never slackened his efforts until he had brought it to pass. There is nothing casual or contingent visible here;

[10] "Federal Aid for Vocational Education" (1917), Carnegie Foundation Bulletin No. 10 (p. v).

no appeal to party convenience, no aim to catch a passing breeze of politics." Senator Morrill may have builded better than he knew; but the success of his enterprise can hardly be cited as proof of his superficiality. Nor can the suggestion of political opportunism be justly brought against a public man who began in 1857 to labor for the betterment of democratic education in his own country, and might be found in 1890 still laboring successfully to the same end.

2.

1862–1887

The literature is filled with controversy about the intentions of the Congress of 1862. A few matters, however, are clear: (1) arrangement of the curriculum was left by the Federal Government to the several states, thus preserving their independence in a question of education; (2) the states were expected, as time went on, to furnish the greater share of the necessary funds; (3) "liberal and practical education" was to be promoted through "such branches of learning as are related to agriculture and the mechanic arts," and that "without excluding other scientific and classical studies"; (4) none of the proceeds from the sales of lands were to be spent on buildings. In view of the confusion which existed among educational leaders when the Act was passed, and in view, moreover, of the constitutional impossibility of imposing educational direc-

tions from Washington, the provisions of the Act seem to be wise, broad and flexible, capable of meeting local requirements and changing needs.

Even if it were possible to discover more definitely what the Congress of 1862 had in mind, it by no means follows that those intentions should prevail to-day. Dartmouth College is not now dedicated to "the Christian education of Indian youth," the original endowment of Williams College can scarcely be said to be used these days for the support and maintenance of a "Free School in Williamstown"; and the students of William and Mary might be surprised to learn that their institution was established as a "seminary of ministers of the gospel, that the youth may be piously educated in good letters and manners, and that the Christian faith may be propagated among the Western Indians, to the Glory of Almighty God." Far too much time has been spent in attempts to penetrate the mind of Congress in 1862. It seems clear that under the broad and rather ambiguous statute the work of the colleges should proceed not from the intentions of sixty-seven years ago, but from the needs of to-day and of to-morrow. And these, in turn, will be discussed in an appropriate place.

The twenty-five years between 1862 and 1887 were barren enough. The lands granted by Congress were, for the most part, sold in a poor market. Many of the states realized less than a dollar an acre from their allotments, and in some cases, the income

from sales price was not sufficient to maintain even one department of a college properly. On the other hand, one must admit that the career of the new institutions was probably not retarded in any important way for lack of funds during the first twenty-five years. For their chief difficulties neither could be nor can be met by money. The colleges "had to create a body of knowledge, give it pedagogic form, and train their own professors." In other words, they had to cut their own road through the educational tangle, and pave it. They felt also, and most acutely, that they were called upon to perform the almost impossible double task of winning the support of practical farmers and securing the sympathy of hostile educators of the old school. Indeed it was even worse than that. They were continually on the defensive against criticism. The most candid of them saw that they were excusing their failure to produce practical results by asserting an interest in fundamentals; and that in the same breath they were defending themselves against the loftiness of the "educator" by claiming to serve the public need of the moment. It may be inferred from the rather testy self-consciousness of the men in the Land-Grant Colleges as it appears in conference records and correspondence of the period, that they were so everlastingly occupied in maintaining their self-respect that there was little time left to think about their task and get ahead with it.

Now and then a voice made itself heard in the

wilderness. There was Doctor S. W. Johnson, who had worked as a student with Erdmann in Leipzig and Liebig in Munich. He had visited the laboratories of Heintz in Halle, Jacoby in Magdeburg, and Rose in Berlin. He had inspected Hohenheim, the agricultural school of Württemburg, and the experiment station at Moeckern. And he had returned to the Yale Scientific School as assistant professor of chemistry. In 1854, from a desk in Liebig's laboratory, he had written home: "If agriculturists would know, they must inquire. The knowledge they need belongs not to revelation, but to science, and it must be sought for as the philosopher seeks other scientific truth. . . . The natural history, the chemistry, in short the whole science of each agricultural plant must be made the subject of careful investigation." In 1873, from his professor's chair at New Haven, he was still urging his view: "We are simply grinding over the old grist which our fathers have given us. I can go to my shelves and take down a history of Roman agriculture and can put my finger on almost all the good ideas which you will hear ventilated in any agricultural meeting in this country—except those which have come within the last thirty or forty years from the investigations of modern science. Why not throw up some broader, straighter, and firmer highways whereon we can travel comfortably without discomfort from dust or peril from mire?"

In 1889, with the Connecticut Experiment Station

(established in 1874) now considerably helped from Federal funds by the Hatch Act of 1887, Doctor Johnson was translating his precepts into practice. E. H. Jenkins, H. P. Armsby, Roland Thaxter, and Thomas B. Osborne were his colleagues. He was proving in fact what he had always maintained in theory—that fundamental research in agricultural science is necessary to the advancement of practice; that work of highest scientific quality can be done under the title of agriculture; and that the sole way of accomplishing the almost impossible double task of gaining respect in the eyes of the practical farmer and the hostile educator is by accomplishing the single task of gaining one's own self-respect first. Of all the discoveries of the remarkable Experiment Station at New Haven, this last is perhaps the most valuable.

In 1887, one who looked back upon the first quarter-century of the history of the colleges might contemplate their future with serious misgivings. Funds were low; sales from grants of land had produced little capital; the states, for the most part, had not begun to meet their implied financial obligations; current enrollment on the agricultural side was scarcely more than an ironic comment on the oratorical flights of 1862; the number of graduates was insignificant; and the institutions themselves, especially those attached to the state universities, were drifting back, discouraged, to the old régime of literature and languages—plus a smattering of

science. We are often reminded of their difficulties: they had no sufficient body of teachable knowledge, no men trained to teach what little they had, and few places where new knowledge could be discovered. Worst of all, however, they had no definite objective and only a half-hearted purpose to find one. In a word, the institutions which had been designed tc meet the educational needs of a young and pioneering country appeared to possess neither the vigoı of youth nor the vision of the pioneer.

3.

1887–1907

Each month, inside the front cover of the "Experiment Station Record," there appears a long list of stations, fifty-six of which are within the United States. The few others are in Alaska and the outlying possessions. They are taken for granted to-day as an integral part of the national system of agricultural research, teaching, and extension. Established in 1887, they too, like the colleges, had their forerunners. Field and laboratory experiments had been started at Rothamsted, England in 1843 by Lawes and Gilbert. Since 1853 the government of Saxony had been giving support to a station under the University of Leipzig, and its work was well known in the United States. In 1871 a bequest of Benjamin Bussey had started the same type of investigation under the auspices of Harvard. Among public institutions, the Connecticut station was a

first-class example of what an enterprising state could do on its own resources. And there were others, so that the Committee on Agriculture could inform the House of Representatives in 1886 that twelve such establishments were already in existence and that many other colleges were doing work of a precisely similar kind as part of their ordinary duties.

When, therefore, in the same year Congress was called upon to consider the Hatch Bill, appropriating fifteen thousand dollars annually to the several states for the establishment and support of agricultural experiment stations, there was all this experience behind the proposed legislation. Moreover, the heads of the colleges and existing stations, summoned by the Commissioner of Agriculture, had met in Washington to let Congress understand that "the condition and progress of American agriculture require national aid for investigation and experimentation in the several states and territories." As an evidence of their earnestness, these academic gentlemen appointed a committee to further the interests of the bill—a reprehensible practice, no doubt, but it proved to be a useful one. The bill became law.

Now the Hatch Act was important. It recognized in a substantial way the place of research in the advancement of agriculture. Provision was made for something more continuous and more comprehensive than the spotty work in fertilizers, seed-

selection, and crop-rotation, which had been going on here and there in the United States, if and when time and funds permitted. Research, it was hoped, would provide the content of teaching, a type of intellectual discipline for the student, and information for the improvement of farm practice. Had the clue been found? Certainly the older men, still with us, remember with a glow the buoyancy of the years which immediately followed this first Federal appropriation for experimental work in agricultural science.

The period of twenty years here under review was a period of expansion and consolidation. To the original land-grant of 1862, which provided funds for the colleges themselves, were added, in 1890, fifteen thousand dollars a year for the institutions of each state, rising by increments of one thousand dollars annually until 1900. Not satisfied with this one increase, Congress took the matter under advisement again in 1907, and in the Nelson amendment to the foregoing Act, made thirty-five thousand dollars immediately available and authorized increases of five thousand dollars annually for the next three years. Each state, therefore, by 1907 was receiving thirty-five thousand dollars plus the proceeds of the original land sales, with the assurance that by 1910 its annual subsidy would be fifty thousand dollars. Meanwhile the states themselves were bending to share the load; by 1892 they were shouldering two-thirds of the four-million-dollar budget of the Land-

Grant institutions. And shouldering it in no grudging way either. For as the cost of instruction increased, as the colleges expanded in numbers, as the activities of the colleges extended both on the campus and into the country, as building after building had to be erected to meet fresh needs, state legislatures absorbed the price of growth and progress, until by 1907 they were carrying more than eighty-five per cent of the vastly increased expenditure. On the experiment station side, Congress in 1906, by the Adams Act, doubled the Hatch appropriation of 1887 to thirty thousand dollars a year, while state and local support, which in 1889 was eighteen per cent of the total, increased over the next thirty-five years, until by 1925 it amounted to eighty-six per cent of a much larger figure.

Certain results during the period from 1887 to 1907 may legitimately be ascribed to the stations. In almost every instance they became physically and spiritually associated with the colleges. Their staffs overlapped; their direction was often united in one and the same individual. Out of this connection, textbooks were produced and teaching was made more attractive through accessions of laboratory knowledge. Enthusiasm was maintained by the leaven of new discoveries. The relationship of the stations to the college induced more men of scientific training to accept positions on the college staff. Their own achievements and influence lent dignity to the teaching and study of agriculture. They pro-

vided a clinic where book learning might be checked and enriched by field practice and experiment. Lastly, by demanding a high type of training for staff positions, the stations gave an impetus to graduate study. Post-graduate qualifications they began to insist upon, until the colleges themselves in the end had to rise and respond to the demand.

So much for the expansion of these twenty years. But there was integration as well: of problems and objectives through the "Association of American Agricultural Colleges and Experiment Stations," organized in 1887, and of research through the Office of Experiment Stations created in the Department of Agriculture in 1888. But though the Department for many years held its membership by right in the Association, and though the Office of Experiment Stations was, in a sense, a centralizing body, it is proper to think of these Federal agencies as integrative rather than directive. Whatever may have been the wishes of the Departments, their representatives have always concurred in the position of independence asserted by the overwhelming majority of states. The law has required the Department of the Interior to receive reports from the colleges regarding the expenditure of funds from the 1890 and 1907 grants. It has received them.[11] The law

[11] Bulletin No. 6 (1924) of the Department of the Interior, edited by L. E. Blauch, contains the following statement:

"The statistics of this report are compiled from reports of the presidents and treasurers of land-grant colleges which those officials make to the Secretary of the Interior and the Secretary

has required the Department of Agriculture, not in the case of the Hatch Act, but in the case of the Adams Act of 1906, to certify to expenditures by the stations for approved research. The Department has done so, and occasionally has withheld its approval. But by and large "control" has not been serious, and the disposition to put the services of the Departments at the command of state institutions has been generous and whole-hearted.

Between 1887 and 1907 the situation of the agricultural colleges underwent important changes. The number of students increased rapidly, government and state support came forth abundantly, research was established, departments multiplied, buildings and material equipment arose to keep pace with needs. The colleges began to find themselves as institutions of higher education. It is easy to write these generalities; it would be equally easy to substantiate them by impressive figures. It is easiest of all to suggest that if the reader really cares for evidence, he should turn to the report of the Association of American Agricultural Colleges and Experiment Stations for 1892, four years after its establishment, and compare its discussions for scholarship, scientific imagination and educational theory

of Agriculture. These reports constitute the principal source of information employed by the Bureau of Education to learn of the work and progress of land-grant colleges. As occasion and opportunity afford, the colleges are visited by members of the Bureau of Education, but in a general way it may be said that the Bureau works with the colleges at long range and primarily through their reports."

with the corresponding report for 1907. He will then not need statistics.

4.

1907–1928

As one turns to the latest period in the history of the Land-Grant Colleges, he feels that so far there has been nothing haphazard about the progress of agricultural education. Certainly in broad outline, it has been on the march. Foreign and local experience—known about, talked about and regarded as indispensable—took shape in the colleges of 1862. So teaching was provided on a nation-wide scale. Foreign and local experience with experimental stations emerged in the Hatch Act of 1887. So research was insured. First a basic fund for teaching, then a subsidy for research; now an increase for teaching, now an increase for research. By 1907 both divisions of agricultural education were grounded in Federal funds, both were receiving generous state support. They were developing together as complementary organs of the same body.

But in addition to the teaching for which they were created, and the experimental work which they came to see that they must do, the colleges acknowledged a third and separate duty—that of extending these teaching and research advantages to the agricultural population. Other institutions might live in cloisters; their own campus was to be the state. "To advance the practice of scientific farming," says

Raymond Pearl, "means to put into the hands of the practical farmer the most complete and authentic information which exists in regard to the scientifically correct principles and methods of farming" and "to stimulate him . . . to put these methods into practice." That, as well as it can be said in a few words, is the purpose and scope of the extension service.

Early in the chapter, mention was made of the few sporadic teaching efforts which preceded the Morrill Act of 1862. Later, some account was given of the several experiment stations whose work was under way before the Hatch Act of 1887. It is now appropriate to speak of the steps which had been taken in the field of extension before the Federal Government lent a hand in 1914. The suggestion is so often heard that our national legislators have given funds for agricultural education out of a clear sky on the strength of some political motive, that it might be well to see what progress had been made by the separate states before the Federal Government intervened.

Two years after the stations were established—that is, in 1889—the Association of Land-Grant Colleges and Experiment Stations held its second meeting. A good deal of time was taken up with the question: "How can stations reach and interest farmers?" The formal papers covering this subject were colorless: the discussion which followed was distinctly second-rate. Professor Morrow of Illinois

claimed that, in the course of the previous winter, doing his bit, he had addressed "twenty-eight or thirty agricultural meetings, mainly farmers' institutes." President Fernald of Maine recommended that "the farmers should have some representation on the board of control of the station." President Willits of Michigan had a suggestion in technique: "If a farmer finds a bug doing some injury, let him write to somebody who is supposed to know something about it and get an answer, and, I tell you, he will feel better. It is something like consulting a physician. He may give you nothing but a bread pill, and yet you will feel better for it afterward." Mr. Henry, director of the Wisconsin station, thought that much could be gained by the proper personal approach. If farmers questioned the value of the work at the station, "I knock them right down at once, and then explain.". . . "You look men in the eyes and shake them by the hand. They go home and say, 'I saw the director and he is a pretty good sort of fellow.'" Professor Henry also thought that it was right and feasible for the station to answer questions which were put to it from the outside. They could be answered through the institution or through the press—"a thousand questions at once, or ten thousand." "It can be done with the aid of a stenographer, and you cannot get along in your station without a good stenographer." Mr. S. H. Ellis, president of the board of control of the Ohio station, was present. "'I am a farmer,' said

Mr. Ellis, 'and have always been a farmer. I have lived on a farm, worked on a farm, raised my family on a farm, and expect to die on a farm.' (Applause.)" Mr. Ellis thought that the bulletins of the stations were useful, but that they could be improved. He remembered, once upon a time, reading an old book with a very peculiar title. "There was a picture of a gladiator with a drawn dagger, and under it the words 'Read me or I will stab you.' Send off your bulletin with something like that. (Applause.) The farmer will become interested, will call the attention of his wife to it, and will ask John to read it."

Now, with all deference to the splendid men who gave their best to agricultural education—and one or two who have just been quoted deserve that description—this was a disgraceful exhibition. Getting nowhere, the conference referred the question to a committee, asking them to formulate and report the sense of the meeting. The sense of the meeting was apparently arrived at by ignoring the nonsense. Beyond that the committee made a few positive suggestions: directors should familiarize themselves with the needs of agriculture and seek the coöperation of state boards and bodies; exhibits of station work might be made at fairs, while local fertilizer and variety tests could be made on private farms; station officers should mingle with the farmers at granges and institutes, and, if practicable, invite conventions to the stations in the summer time.

Finally, state organizations and the press ought to be utilized for spreading scientific information of practical value to the farmer. "Your committee realize," was the modest conclusion, "that all of these methods may not be applicable to each state, but trust that the enumeration given may present a field in which each state may find one or more suited to its needs."

In contrast with the chaotic conditions which prevailed with regard to extension work in 1889 and the amazing inadequacy of the program suggested, a statement follows of the actual extension service of 1909, the year in which the Association of Land-Grant Colleges and Experiment Stations was enlarged to include extension as a separate branch. Unless the reader has some special interest in this classification, he will not need to labor through it; a glance will show how many rational steps, all without Federal aid, had been taken since the fumbling and ineffectual session of 1889:

Aspects of the Extension Service

A. Definite systematic instruction, or formal teaching:

1. The lecture course: Given under the auspices of various clubs and organizations, one night a week for several weeks. These lectures should deal with definite topics, and the course should continue long enough to deal with that topic completely.
2. The reading course: This should be drawn up by the college in coöperation with the state education department. It will be pursued by the stu-

dent at home. Provision should be made for giving help by correspondence.

3. The correspondence course: Subjects are prescribed and questions set by the college. The answers are sent to the college and returned to the student when corrected.
4. The movable school: Lasting from one week to one month, and conducted as a school, but itinerant in character.
5. Permanent demonstration plots or farms: The value of certain methods of cultivation or varieties of crops is demonstrated right at the door of the farmer.
6. Study clubs of various kinds, such as boys' corn clubs, girls' canning clubs, poultry clubs, and the like.

3. Teaching that is more or less informal, advisory or suggestive:
   1. Conventions:
      a. Farmers' institutes: These are conducted by the colleges in many states. Where they are not conducted directly by the college, they look to the college for assistance.
      b. Conferences on special agricultural topics, such as dairying, poultry-raising, fruit-growing, and the like.
      c. Teachers' institutes for agricultural purposes.
   2. Itinerant lectures:
      a. Miscellaneous lectures on call, and under many auspices.
      b. Traveling advisers, or field agents.
      c. The permanently located expert or adviser, for a county or other prescribed district.
   3. Object lessons:
      a. Field and platform demonstrations: less formal

than demonstration plots and more readily movable in character, such as spraying demonstrations.

b. Educational exhibits at fairs: stock-judging, corn-testing, and the like.

c. Excursions to the college to study experiments or to see demonstrations.

d. Special trains, railroad cars, or vans carrying agricultural material for educational purposes.

C. Coördination and coöperation:

1. Holding "conferences on rural progress," to bring together all the people interested in rural life for discussions of the larger problems of rural betterment.
2. Coöperation with other agencies and activities, such as chambers of commerce, boards of trade, manufacturers' associations, labor organizations, and the like.[12]

In "Science" for May 9, 1913, in an article firmly critical of the quality of scientific research in the agricultural stations, Raymond Pearl admitted that "on the whole, it would be difficult—and indeed no one has ever done so—to devise a better and more effective system for the promotion of scientific farming than that which we now enjoy the benefit of in this country." So, one year later, when the Smith-Lever bill came up to Congress, it was not a matter of floating some politician's whim on the wave of public funds; it was a question of enriching

[12] Adapted from "The Means and Methods of Agricultural Education," by Albert H. Leake (1915).

and coördinating existing work. By and large, the work is truly coöperative in spirit as between the Department of Agriculture and the colleges which direct extension locally. On the financial side, coöperation can be measured without great difficulty. Under the Act of 1914, and a supplementary Act of 1919, Congress provides $7,101,000 annually, and the various states, as the Act stipulates, offset this grant by contributing $4,100,000 of their own. This much is fixed; but it is interesting to know that, over and above this sum, the states freely vote an additional seven million dollars a year.[18]

Aside from this impressive development in both funds and program, the extension service, during the past twenty years, has been largely responsible for the growth of the fields of agricultural education, home economics, and agricultural economics. This has come about naturally. People in extension have always maintained that the scope and usefulness of the colleges could not be determined, for good and all, in the academic sanctum or in the scientific laboratory, and that since agricultural education is intended to help the farmer wherever he may be found, it is important to know what help he would like to have. For the most part, until the extension service found its feet, teaching and research were concerned with the man on the farm and his power

[18] Adapted from table 20 of the Annual Report on Coöperative Extension Work, U. S. D. A., 1923.

to produce. During the last twenty years there has been a phenomenal growth of interest in the women and children, and in the man's power to market his produce profitably. These were previously gaps—bad gaps. Now, so far as the structure is concerned, they have been filled in. Local funds have long since been forthcoming, but in 1925, by the Purnell Act, the Federal Government took a hand. Under this Act each state may look forward to an additional annual appropriation for research which will finally amount to sixty thousand dollars. Technically, these are free funds, for such use as each experiment station shall determine; but the Act so obviously intends that the two fields of agriculture and home economics shall be explored that a good share of the sum will doubtless be employed in this way.

5.

Teaching, research, and extension—that is the stereotyped division of the work of the college. But just as, in addition to the institution's program of scientific discovery, research men and women have been trained for their future positions; just as, in addition to the extenson activities of the resident college staff, extension workers have been prepared for their careers, so, in fact, the training of teachers has always occupied a place in the scheme. For years this responsibility was discharged without Federal help, except that permission was granted to use part of the Nelson appropriation of 1907 for the pur-

pose of training teachers. In 1917, however, the Smith-Hughes Vocational Education Act supplied funds expressly for the purpose, and during the last decade, teacher-training activities have moved forward vigorously.

There was no national and indeed no general scheme of secondary schooling in agriculture until 1917, when the Federal Board for Vocational Education was created by Act of Congress. Aside from encouraging and supporting institutions for the disabled worker (an important, but separate function), the Board assists in establishing units of teaching in agriculture, home economics, trade, and industry in secondary schools in every state of the Union. If the character and amounts of vocational instruction proposed by the school and ratified by the state authorities meet the requirements of the Board, and if either local or state funds can be found to equal the proposed Federal subsidy, one or more such units, as desired, can be introduced into the school curriculum. So far, in the short history of this rather new venture, nearly three thousand schools have *undertaken to give complete secondary courses in* agriculture, not including evening and part-time classes. More than three thousand teachers (all men) are engaged upon this work, nearly seventy thousand pupils are enrolled, almost two million dollars of Federal money were spent in 1925; while state and local subsidies, generously outstripping the Board's grant, reached a total of approximately four

million—or two dollars to offset every dollar received from Washington.

Reference should be made, however, to two aspects of the Act of 1917 which have caused embarrassment. The states, from the beginning, have tried to maintain complete freedom in the field of education. Whenever Congress has offered a conditional subsidy for agricultural research or education, their position has been stoutly reaffirmed. The Act of 1917 represents the furthest extent to which Washington has gone in the way of control. In its official answer, published in 1918, "to inquiries concerning matters of policy," the Director of the Federal Board for Vocational Education stated that the Act set up "very definite and far-reaching principles, standards, and restrictions." "We also see in this Act," he added, "the culmination of a series of progressive steps from the granting of Federal moneys with very few restrictions, to the granting of Federal moneys under certain definite standards and with certain definite restrictions concerning the expenditure of the moneys." Those who fear the encroachment of Washington upon the educational activities of the separate states have some ground for anxiety over the apparent trend in recent Federal legislation.

The second difficulty is this: in the Smith-Hughes plan of vocational instruction the pupil (whether boy or girl) learns the practice of agriculture largely through first-hand experience. Each pupil undertakes a "project"—a small agricultural enterprise

which he may reasonably be expected to bring to a successful conclusion. At first it seemed best to carry these projects out on a school farm, under direct supervision. It has since seemed wiser to transfer them to the individual farms on which the boys and girls live. Now before the Smith-Hughes Act was passed, projects like these, though not related to school instruction, had been going forward under the title of extension. Boys and girls had been brought together in clubs to engage on separate or coöperative farming projects. Their work had been supported and guided to a considerable extent by the appropriate division of the Department of Agriculture, and it had been directly supervised in the various states by club leaders attached to the state extension division. It was natural therefore that when the Federal Board for Vocational Education (an "administrative upstart") entered the same field, rivalries were aroused between two branches of government, both in Washington and in the field, which are by no means cleared up. In some states a compromise has been worked out. Children in school come under the Smith-Hughes scheme; children who are not of school age remain under the Division of Extension. In other states, a merger has been effected, not wholly ideal, by making the former club agents the new teachers in Smith-Hughes schools. In general, the tendency seems to be toward a closer integration of all farm project work with school instruction.

With a good deal of truth, the report of the Vocational Board for 1918 concludes: "We see in the Smith-Hughes Act a rounding out of a nation-wide system of agricultural education." At the center of the system, whether viewed structurally, functionally, or historically, stands the college. In the educational field to-day there is an air of hopelessness: it is claimed that work at the college and university level cannot be substantially improved until the schools are bettered. On the other hand, nothing can be done about the schools, until and in so far as the colleges supply better teachers. This dilemma is not easy to meet in the case of private institutions, nor in the case of public institutions when they are concerned with general education. But in the agricultural field, we have, in a sufficient sense of the word, a system, with the college as a nucleus. It is not inconceivable that the quality of work from top to bottom might be more spectacularly advanced by some other agency, or through some new device. But once having recognized the place which the college occupies, and its germinal influence in the whole field, we cannot turn elsewhere until we have fully examined its situation and its possibilities.

CHAPTER IV

SERVICE AND EDUCATION

1.

The record of the agricultural colleges from their foundation in 1862 until about 1890 was not very creditable. Instruction, for the most part, consisted in passing on to the younger generation certain farm practices which had been empirically found to be useful.

In 1894, in all the Land-Grant Colleges, there were about 2,700 enrolled, including short-course students and those in colored institutions. These figures may be compared with the 15,000 resident students registered twenty years later for agricultural degrees in white institutions alone. In 1889, Milton Whitney of the South Carolina Experiment Station protested that his duties were heavy: "My own position, for instance, embraces, in addition to the vice-directorship of the station, the professorship of agriculture, horticulture, animal husbandry, and meteorology in the college." At the same meeting of the Land-Grant College Association, President Atherton referred to the handicaps under which beginnings had been made: "There were here and there," he said, "men devoting their time to science, like Gray,

Agassiz and Dana; but there were not teachers enough to man an institution in any one state, not to speak of the whole number throughout the Union."

What is more, not much constructive thought was given to the educational problem. The Association minutes of the 1889 convention are illuminating. Said Doctor Armsby: "We had a very interesting meeting of the Experiment Station section yesterday, but we met under a disadvantage in not knowing what we were going to talk about. . . . We sat and looked each other in the face, and wondered why somebody didn't say something." Mr. Raub of Maryland had been quite uneasy: "When I received the programme," he said, "my first impulse was to stay at home, and I have been nervous about this meeting ever since." There was also evidence of a lack of interest which would be utterly unimaginable in 1927. "Unfortunately," run the minutes of the 1889 convention, "not one of the college presidents invited to open the discussion on the subject of 'The Primary Obligations of the Colleges and Stations under the Hatch Act' is present."

Yet the creation of these stations soon proved to be the step by which the colleges saw the potentialities of their task. A growing body of information tested according to the best scientific knowledge became available, and it became apparent that the colleges were not excrescences upon the body of society, but useful organisms to the State and to

the individual. From the moment that they understood that they had work to do, bigger than themselves, basic in character, and affecting half the population of a developing country, they rose in stature and have continued to grow ever since. The agricultural college, therefore, without sacrificing that self-respect which it has been years in building up, can confidently afford to ask itself what it is doing, where it is going, and how wisely it is spending other people's money.

2.

In each state of the Union, and in the territories of Alaska, Porto Rico, and Hawaii, there is an institution of higher learning supported by government, in which agriculture is taught. There are, therefore, fifty-one in all.[14] In about half these states and territories the agricultural college is a part of the state university: elsewhere it unites with an engineering division to form a separate establishment, located many miles from the university, with its own organization and its own buildings.

Massachusetts Agricultural College occupies a unique place. For though other institutions, like Kansas State Agricultural College, are known under

[14] There are also seventeen agricultural and mechanical so-called "colleges" for Negroes in the Southern States, supported by Federal and State funds. They have a growingly important place and they deserve careful study. But since their standards are definitely lower than those of white institutions and their objectives even more obscure, it would be confusing to include a discussion of them in this report.

the same descriptive title, Massachusetts is the only Land-Grant College devoted exclusively to agriculture and "subjects related thereto." The Institute of Technology at Cambridge receives that portion of State and Federal funds which is provided for engineering; other branches of higher learning are taught in other institutions of the Commonwealth. Thus, strictly speaking, the only purely agricultural college in the country is the one at Amherst. The distinction, however, may be disregarded in any general survey, for its situation is essentially like that which exists in the combined agricultural and engineering colleges.

So far as their "terms of reference" are concerned, both groups proceed from the statute of 1862; their "leading object shall be, without including other scientific and classical studies . . . to teach such branches of learning as are related to agriculture and the mechanic arts." So long as they continue to act within these wide terms of reference, they will receive financial support from the government. It is, of course, a commonplace to point out that they differ, not only as between the two major groups, but individually within the groups themselves. They differ in numbers, standards, salaries of teaching, research, and administrative staff; in the amount of time, thought, and money which are applied to teaching, research, and extension, respectively; in their attitude toward fundamental science; and toward so-called "cultural" subjects; in the extent to

which they regard themselves as local or more than local instrumentalities. They also differ in their ideas of what they are trying to do.

First of all, they are known by all sorts of names. Here are some at random: Alabama Polytechnic Institute, Alaska Agricultural College and School of Mines, University of California, Purdue University, Kansas State Agricultural College, Michigan State College of Agriculture and Applied Science, Rutgers University, Clemson Agricultural College, Virginia Agricultural and Mechanical College and Polytechnic Institute, State College of Washington.

So far as enrollment in agriculture is concerned, they likewise vary widely—from two students taking degree courses in this subject in Alaska and twenty-eight in Delaware, to 677 in Texas and 765 at Ames, Iowa, in 1925. Expenditures also show a great difference. In the same year (the last year of full figures from the Department of the Interior), over nine and a quarter million dollars were spent by the University of California for all branches of higher instruction, while less than half a million were spent by the University of Delaware. In the group of non-university institutions, Connecticut spent less than half a million, while Ames accounted for four and a quarter. In this latter group, funds were disbursed, of course, not for university instruction as an entirety, but for agriculture, home economics, veterinary science, forestry, and the mechanic arts.

Likewise, standards of college instruction differ not

only as between the two groups, but within the groups themselves. Doctor East of the Bussey Institution has made the following comment: "The work given in the institutions supported by the wealthier states, such as New York, Wisconsin, Pennsylvania, Ohio, Illinois, Michigan, Minnesota, and California, compares favorably with that in other first-class colleges." And he adds: "It is hardly fair to criticize the college instruction given by the weaker State institutions. No doubt it is often bad. But it is certainly no worse than that given by the weaker endowed institutions." The correctness of these views is not, at the moment, under consideration. They are introduced at this point to indicate the great differences in standards among the Land-Grant group, rather than to compare their quality of instruction with that of the endowed colleges.

On the post-graduate level, about three hundred and seventy-five masters' degrees were awarded in 1925 in agriculture alone, together with about fifty doctorates in the same field; but though forty out of fifty-four institutions directed work toward the master's degree, only eight—and all of these were universities—undertook to confer a doctorate. Out of these eight, Cornell,[15] Wisconsin, and Minnesota contributed more than two-thirds of the higher degree men.

[15] Cornell's situation should be defined. It is not a state university. It is an endowed university with which three state-supported colleges are affiliated.

In the majority of cases, the experiment station is an integral part of the college or university.[16] Men and women on its staff perform double duty in teaching and research, and the work of the two branches goes forward together. But in a few states there is an almost complete divorce of the work of the station from that of the college. No law requires a merger: financial advantages, personal difficulties, and theoretical ideas have brought about the separation. Differences likewise appear in the amount of attention which various institutions give to the cultural, the practical, and the scientific subjects; and in the amount of emphasis which they place upon teaching, research, and extension respectively. The heads and staffs of some institutions are men of thorough scholarship and advanced training. In other cases, as in some of the endowed colleges, they are essentially "contact" men, politically minded, intellectually superficial, voluble, and pompous.

In one way or another, on instruction, administra-

[16] "In each of the States the agricultural experiment station is under the management of the land-grant college, except as follows: 1. In Ohio and Georgia the experiment stations are entirely separate from the land-grant college, except that in Georgia three members of the experiment station board are also by law members of the board of the college of agriculture; 2. In New York the Federal funds are divided between two stations, both of which are now (1923), under one director and under the land-grant college board of trustees; 3. In New Jersey and Connecticut, each, there is a State station and an agricultural college station, in each case under the same director." From United States Bureau of Education Bulletin, 1924, No. 6: Statistics of Land-Grant Colleges, June 30, 1923, p. 2.

tion and permanent improvements, on interest on invested capital, on research and on extension activities, the Land-Grant institutions spent, in 1925, the sum of twenty-eight and a quarter million dollars.[17] The total may be divided as follows:

Interest on capital investment	$1,875,000 [a]
Instruction, Administration and Improvements	9,443,300 [b]
Experiment Stations	9,394,141 [c]
Agricultural Extension	7,500,000 [d]
Total	$28,212,441

This sum, exact in some items, conservatively estimated in others, represents the amount disbursed for agriculture, forestry, and veterinary science. And if the allied field of home economics be included, the amount should be increased to more than $37,000,000 yearly. In this total, the expenditures of the seventeen Land-Grant institutions for Negroes in the Southern States are not included; nor are the forty-four millions which the Department of Agriculture spent in 1925 for the conduct of its administrative, regulatory, research, and extension activities; nor the ten millions which federal, state, and local author-

[17] [a] United States Bureau of Education Bulletin, 1925, No. 44. Capital investment of all institutions taken. Proportion of capital investment attributable to agriculture arbitrarily estimated on proportion that number of students enrolled in regular agricultural courses bears to whole number in all institutions. Interest reckoned at 5%.

[b] Same basis used for estimating proportion of annual income.

[c] Figures on page 46, column 4 of above bulletin. Increased by amount of Purnell appropriation for 1925.

[d] Estimated on basis of figures which include both agricultural and home economics extension, p. 48, column 6.

ities spent for vocational education in agriculture at the secondary school level.

An annual subsidy of more than ninety million dollars, of which about a third is spent by institutions of higher education on agriculture, forestry, and veterinary science, is a considerable sum of money, whatever comparative statistics may tell us as to the corresponding amounts put into cosmetics, tobacco, and the United States Navy. Almost all of this is contributed by the taxpayer and he feels that he is entitled to know what good comes of it. The expenditures of the Department of Agriculture are not seriously questioned: the ordinary citizen pays little attention to the huge cost of government in all its branches, nor does he often claim to be a competent judge of such matters. On the other hand, it is his prerogative to criticize the way money is spent on public education. If he is not a farmer, he objects to what he regards as a subsidy to a favored industry: if he is a farmer, he is apt to think that, though the subsidy is right enough, it ought to be expended along more profitable lines.

3.

Now there can be no reasonable doubt that every cent that comes out of the nation's pocketbook or out of the state's pocketbook for higher agricultural education is returned to the state and nation many times over. It would be possible, of course, to go through the itemized budget of any one of these

institutions and question the estimated economic value of this particular expenditure or that, but, taken as a whole, the return is abundant. Cornell, in a summary bulletin covering the year 1926, lists the following annual profits to New York farmers from the discoveries and direction of the college:

Saved by poultry culling	$117,760
Extra profit, alfalfa acreage	300,000
Value of weather forecast	122,000
Apples saved by one direct spraying	200,000

These are merely a few examples from a long list. The resistant Robust bean, introduced into New York by Cornell, has saved the pea-bean industry; 90% of the wheat acreage is planted to three varieties of wheat, two of which were developed by the college and the third recommended by it; 30% of the oat acreage is in college-bred strains; while station-tested clover and alfalfa yield 20-50% above the ordinary market seed. Taken as a whole, the increased yield of grains introduced by the college are 10-15% above those of the commercial varieties which they have replaced. Cornell's estimates could be matched by similar claims from every agricultural institution in the United States. Sometimes the figures seem arbitrary or extravagant; but even at a drastic discount the economic services of the colleges and experiment stations run into hundreds of millions each year.

These are simply the results of research, or of the

application of research to practical agricultural problems. In addition, each institution gives undergraduate instruction to a varying number of students—some will return to farming, others will go on into research; some will enter the teaching field, others will become leaders of farm organizations. About eighty to eighty-five per cent of those who receive undergraduate instruction in agriculture will enter that field of work through some one of the main gates. The percentage of those securing the master's degree who follow agricultural pursuits is still higher; and it is a rare event when a man who has taken his doctorate in agricultural subjects forsakes this field for something else. For example, thirty doctorates in entomology have been granted by Ohio State University in the past twenty-five years. Of these thirty advanced students, two, in 1927, were heads of divisions in the Bureau of Entomology at Washington, one directed the research work of another bureau, six were heads of departments in universities, others were in charge of state entomological work, while only one returned to private life, and even he devoted a period of years to research in South Africa before his retirement.

"We have come to a day of accounting," says Doctor Kennedy of Ohio, "when we have to measure the output of the University by the amount of service it renders the state in return for the taxes paid to support it." [18] Can there be much doubt of the cash

[18] School and Society, April 30, 1927.

value of agricultural extension? The Farm Bureau, in New York State, is the principal agency through which agricultural advice is passed on by the college to the farmer; yet the state dog tax exceeds by a large amount the total cost of all these bureaus. There can be no doubt that research returns its expenditure to the state many times over. Graduate work leading to the doctor's degree pays for itself by multiplying leaders in the field of teaching, research, and extension. A question might be admitted, however, concerning the economic value to the state and nation of undergraduate instruction for the profession of farming. Only one in a hundred farmers the country over go to college; only a third, even of these, go back to the farm after completing their undergraduate studies, and it is arguable that public money spent on these few individuals brings no great social advantage.[19] Absolutely this may be so: yet relatively it is not so. The social usefulness of men so trained is doubtless as great as those trained by state universities in the arts and sciences,

[19] A friendly critic contests the argument: "I doubt the soundness of this challenge of the undergraduate institution. The gradual infiltration of college trained men into the farming communities is having results of great significance to practical farming. They have already become, and are doing so increasingly, the leaders in both local, county, and state farmers' movements, such as coöperative organizations and societies. Evidence could be brought to bear to show that the national investment is justified, particularly as this same investment cannot be segregated for training prospective farmers alone, but is utilized at the same time for all of the other functions of the college, including the training of teachers and investigators."

in law, engineering, dentistry, and medicine. The money-making ability of the individual is enhanced, his personal horizon is broadened, he may be expected to take a more important place in his community than the man without a college education. Agriculture or the History of Art, B.S.A. or A.B., it is all the same. The chief difference is that, for some reason, the agricultural college or the agricultural division of the state university is held to a strict accounting, while the other branches of education (by some kindly remission) are scarcely ever called upon to total up their return.

4.

Take the case of the Georgia State College of Agriculture as shown by President Soule's annual report for 1926-1927. The institution is young, the staff is comparatively small and not very highly trained, the state has never put a great deal of money into education, and has not much to put in. Yet undergraduate instruction was given to 779 students, of whom 178 were in agriculture, 118 in home economics, 56 in physical education, 13 in veterinary medicine, and 331 in the collegiate summer course. More than 2,300 other students were given brief tuition at the college student camp, and in dairy and cotton-growing courses. The extension department had 12,000 boys and 8,800 girls enrolled in club work for the improvement of agricultural practice. Three hundred thousand adult farmers and their

wives were reached—if only superficially—at farm and home demonstration meetings and at general agricultural conferences. Each day the college sent over the radio a crop and market report, a paper of timely rural interest, a talk on some phase of home economics, and answers to a selection from the agricultural questions submitted by the radio audience. The newly established experiment station conducted investigations along a dozen different lines of importance to Georgia's rural life. Members of the college staff visited 273 schools during the spring vacation and gave high school students some realization of the value of a college education. The institution conducted a school of coöperative marketing, a rural ministers' short course, a "Milk-for-Health" campaign, several contests in cotton and corn production, and an egg-laying contest. A survey was taken of swine sanitation in Georgia, and a forest nursery was established. The President's report claims, and itemizes its claims, that practically $17,000,000 was made or saved to the State of Georgia by the work of the college during the academic year 1926-1927. Against this the state contributed $275,000, receiving a return of sixty dollars for every one expended. . . . Yes! The agricultural college is a sound investment. Teaching, extension, and research might be better, but they pay their way. The economic return might be higher, but it clearly shows a balance in favor of society over and above annual expenditures.

The leaders of higher agricultural education would do well to rest on their oars and ignore the partly real, partly imagined criticism that they do not render enough service to the state "to pay for their keep." They do, and if their present efforts cannot convince their critics, nothing can be gained by further enlargement of activities along these lines. Attention might be given, however, to the other main criticism with which they are beset, this time from academic quarters. And whatever inherent truth there is in academic criticism should be sifted out, even though this criticism proceeds from circles which are traditionally hostile—and rather ignorant.

Such criticism, when put most fairly, reads somethink like this: We acknowledge your earnestness and devotion to the interests of the state, we recognize the valuable services which you perform; but isn't there something lacking, partly because you do engage in so many different forms of activity and partly because you feel yourselves forced to show a tabulated annual economic return? Be frank about it. Don't your spirits rise and fall as the number of undergraduates rises and falls? Don't you feel that you have to keep a weather eye always open, not so much to the real public need, as to your legislative bodies? Don't you hide away somewhere in your budgets the sums of money which are spent for long-term fundamental research and placard the countryside with stories of your "short-course" enrollments

and your Radio Extension Service?[20] Isn't your research program handicapped by the imagined need of showing results, and showing them each year in some way that can be totaled up in figures? Aren't your staff men bothered to death with extension appointments, hand-shaking, seed-testing, bug-identifying, vaccine preparation, and what-not? In a word, be honest with yourselves—are you chiefly an educational institution or a service station?

And the equally candid reply would be something like this: We have two main objectives—one to serve the economic welfare of the state and nation through improving the science and practice of agriculture, and bettering the conditions of rural life; the other, to give the best education we can to undergraduate and graduate students to fit them for their future work, which, in all probability, will lie somewhere in the agricultural field. We are conducting an experiment which is partly economic and partly educational. We are achieving both ends fairly well, but perhaps we are a bit like the "dual-purpose cow" which some of us have been working on for years, hoping to produce an abundance of meat and an abundance of milk off one animal, and, so far, not

[20] *Science* for March 15, 1924, describes such a course conducted by the Kansas State Agricultural College: "The lectures, interspersed with music, lasted for one hour each evening, and included for the five evenings poultry husbandry, dairying and livestock, crops, truck crops and soils, agricultural economics, and home economics. Written examinations were provided for enrolled students at the completion of the course, together with certificates of graduation."

producing either with conspicuous success. If you think that we have overemphasized the economic side to the injury of our resident education, we will admit that we think the same thing ourselves: and a fair-minded study of our institutions would show better instruction on the collegiate level than obtained ten years ago, more intelligent direction, better qualified teachers, a distinct advance in the standards of research, postgraduate work of high grade in a few institutions—in fact, a definite trend toward scholarship.

5.

Now these institutions must, by their very nature, continue to discharge both economic and educational obligations. The precise way in which they should be discharged has not been clear in the past, and at times there has been conflict between the two objectives. It would seem, however, that if the needs of agricultural practice, and the requirements of education are both reviewed in the light of the present, one useful maxim will appear.

For what are the fundamental problems of agriculture? The best virgin land is exhausted. The old-time profit from a rise in land values cannot be counted on any longer. There are problems of the moment: that of increasing the available acreage by conservation, forest protection, irrigation, dry-farming, and by the development of cold-resistant strains of food-plants. Thereby the crop-producing area

can be enlarged. There is likewise the chance of increasing production by bringing the art of the ordinary farmer up to that of the better. But regarding production alone, and looking only a few years ahead, the pressing question is this: how can production per acre be increased? This can only be done by improving soil conditions, combating pests and diseases, breeding strains which resist disease, and breeding more productive plants and animals. These are the fields of chemistry, biology, and physics. This is the language of plant geneticists, morphologists, physiologists, soil chemists, physicists, and microbiologists, the language of animal physiologists and pathologists. Or if we leave the field of production, and go into the field of marketing and distribution, we find that the leaders of thought in agricultural economics are looking more and more for principles rather than for panaceas and are convinced that these governing principles can be found only where broad scholarly training in economics itself and economic history underlies and coördinates the voluminous results of field research.

And what are the needs of agricultural education? That farmers should be trained to be better farmers? Yes: but not as a major affair of the colleges. There are now 14,000 men and women pursuing agricultural work of a kind which cannot be carried on even passably without broad collegiate training. They are teaching the art or the science of agriculture in the colleges, they are working in experiment stations

or in the Department of Agriculture, as county agents, and as teachers in secondary schools. The annual "turn-over" in these positions of public responsibility is almost exactly equal to the number of graduates, each year, from the agricultural side of the Land-Grant institutions. There is no one of these positions which does not call for a broad education, a vivid imagination, a developed capacity for leadership. And since the highest qualifications are more and more exacted of candidates for these influential positions, so the agricultural colleges should, above all else, prepare them for their work by establishing and maintaining standards of scholarship second to none in the country.

Or to regard the situation from a slightly different angle: There are two elements upon which both economic agriculture and agricultural education depend—one, the discovery of facts and principles now unknown; the other, the dissemination of already known facts and principles to those who are to apply them. The first is the function of research, the second is the function of extension. In theory, they should be driven shoulder to shoulder; in practice, they do not move in this fashion. Either one forges ahead, or the other; and for years past, for various reasons, the extension idea has led the team.

Where the extension idea prevails, teaching consists of instruction in practical farming skills, embellished with some science; the number of students admitted provides the criterion of the institution's

success, and the standards of admission are relatively low. Though there are exceptions, this is the trend. But there is another conception of the business of an agricultural college which contends with the foregoing: that it should primarily train research workers, teachers, and leaders of agricultural progress. Those who believe in this second theory have fought to establish it and have been, in a measure, successful. They have been so successful that no agricultural college has become wholly a vocational school. But they have not succeeded, even in the state universities, in effecting a dedication to the advancement of scholarship, either in the spirit and method of teaching or in the quality of experiment station work.

Research and extension, it seems, cannot be promoted evenly by the same directing energy. One or the other must dominate—and whichever dominates will affect the character of the other, and the character of teaching. However adequately or inadequately these colleges have met the needs of the past, it is now a question whether they can meet the needs of the present and of the future. If the need is for well-trained men, can it be satisfied except through the very best training—through instruction dominated by the spirit of research and moving, in some wide field at least, on the university level?

CHAPTER V

SCIENCE, AGRICULTURE AND EDUCATION

1.

Agriculture is a meeting-ground of the sciences. Physics and chemistry lie at its base. To these elements biology adds its conception of organism. Mathematics is their common instrument. On the way to the application of these basic sciences to practical agricultural problems stand physiology, genetics, nutrition, pathology, entomology, parasitology and the sciences of the soil—derivative subjects which deal with plant and animal life in health and disease. Scientifically defined they are concerned with the nature of life in its evolutionary and pathological aspects. They may or may not be applied sciences according to the temper of the individual investigator and the latitude which his institution allows him. Further still from the base lie horticulture, agronomy, and animal husbandry, commonly regarded as fields of practical application, where work is often empirical and where "results" are chiefly sought, rather than knowledge concerning the phenomena of life. But even here work need not be less scientific than in the foregoing groups. For as the

BASIC SCIENCES

(MATHEMATICS)

CHEMISTRY | BOTANY | ZOOLOGY | PHYSICS | GEOLOGY

FUNDAMENTAL AGRICULTURAL SCIENCES

Plant and Animal

SOIL SCIENCES	PHYSIOLOGY & NUTRITION	GENETICS	PATHOLOGY	PARASITOLOGY	BACTERIOLOGY	ENTOMOLOGY
1. Soil Chemistry	Organic Chemistry	Cytology	Mycology	Physiology	Dairy	Physiology
a. Inorganic	Physical Chemistry	Physiology	Bacteriology	Biochemistry	Soil	Biochemistry
b. Organic	Biochemistry	Biochemistry	Anatomy	Bacteriology	Fermentation	Parasitology
c. Physical	Biophysics	Morphology	Histology	Protozoology	Plant and animal pathogenetics:	Morphology
2. Soil Physics	Anatomy	Taxonomy	Physiology	Mycology	a. Physiology	Taxonomy
3. Soil Mocrobiology	Histology		Parasitology	Entomology	b. Biochemistry	
a. Physiology	Bacteriology		Immunology	Helminthology	c. Taxonomy	
4. Soil Microbiology					Immunology	
a. Protozoology						
b. Soil fungi						
c. Bacteriology						
d. Physiology						
5. Soil Geology						

(BIOMETRICS*)

APPLIED AGRICULTURAL SCIENCES

A. PLANT INDUSTRY

1. Agronomy
2. Floriculture
3. Forestry
4. Horticulture
5. Olericulture

B. ANIMAL INDUSTRY

1. Animal Husbandry
2. Apiculture
3. Dairy Industry
4. Pisciculture
5. Sericulture

* While a knowledge of biometrics is not necessary to all problems in the fields of the fundamental sciences, yet in the majority of cases the application of such knowledge is of importance to the planning of experiments and the interpretation of the resulting data.

field of biology has been divided for working purposes into its physiological, evolutionary, and pathological aspects, so here again it is divided into its various plant media. These media may be investigated if the horticulturalist wishes, or they may be produced more abundantly, as in these days he is more likely to wish.

2.

In two other fields of applied science, medicine and engineering, there have been notable qualitative advances during the first quarter of the twentieth century. This development has been particularly evident in medicine, as it has sought incorporation within the university as the logical goal of its scientific aspirations. Somewhat conflicting interests are involved, for while "the medical school by tradition and in fact has the responsibility of furnishing the people with well-trained physicians in sufficient numbers, the university as such is concerned only with research and with the conservation and propagation of knowledge." [21] But there is good hope of resolving the conflict if medical students so master the inductive technique that the scientific method becomes part of their daily thinking and behavior.[22] Along this path, it is believed, the needs of medicine and "the idea of a university" can both be harmoniously served.

[21] McLean, *Science,* May 27, 1927, p. 511.
[22] Abraham Flexner, *Medical Education,* 1926, p. 13.

Agriculture, as yet, has not gone so far. Yet its claims are greater than those of engineering and fully as great as those of medicine. Mere existence does not require industry, and a considerable part of humanity could survive without medical science; but life itself cannot exist independent of agriculture. For in the last analysis all food comes from plants. It is agriculture's business to produce them so that they may be eaten raw, cooked, milled, fermented, or transmuted into the flesh of lower animals. That is a fact none the less profound because it happens to be obvious, and it is a further obvious fact that the potentialities of plant and animal production must be increased to meet the needs of an expanding population. Now this has never been done nor can it be done except through the discoveries of science. Just as medicine for the prevention and cure of disease turned its back upon empiricism and accepted university standards for its goal; just as engineering with the resources of an advanced industrial civilization followed in the wake of medicine, so agriculture, traditionally slow to forsake its empirical methods, must follow in their course as best it can.

It must be understood, however, that institutions of agricultural education are still at a disadvantage. In the first place, while they deal with the natural sciences and their applications, they also deal with social and economic problems. Again, as professional schools, they assume to train both practical

farmers and agricultural leaders. These duties, as things are, compete with each other; indeed, so long as any institution tries to accomplish both ends through the same curriculum, there can be little hope of its doing university work. But if it is minded to train leaders in research, teaching and extension; and if it believes that these efforts will be fruitful to the degree to which university ideals prevail, it might be able to realize its belief, without compromise, in some large division of its work. No institution of whatever character would undertake to lift its whole self bodily; it would have neither the funds to do so nor the suitable men. But one essential field in which conspicuous progress has been made over the last quarter century, one which in a commercial age seems to be suffering from the spectacular growth of applied economics, is that of the fundamental sciences. Here, now nearest of all to the university level, there is promise of a development of double service to agriculture and to education.

3.

Surely these sciences are proper subjects for inclusion within the university discipline. Surely any matter so basic as agriculture requires the best that cur educational régime affords. It is impossible to agree with those who think that the sciences of production need a long, long rest; that it is useless to agitate them further until the agricultural com-

munity learns to market what it can now produce. The science of production is nothing but another name for accurate knowledge concerning the laws of plant and animal growth in health and disease; and this knowledge can be put into practice or pigeon-holed as economic conditions dictate. More fundamental science means nothing more alarming than more trustworthy knowledge. We can do with a great deal more of that.

There is much, too, in what the late E. D. Burton said when he became President of the University of Chicago. "It has long been a favorite theory of mine that agriculture could be made one of the most cultural in the whole range of studies and an agricultural school a center of a very high type of culture. For has not agriculture intimate relations with chemistry and physics, with botany and zoölogy, with transportation and with commerce, with banking and the development of society, and with politics? Has it not indeed its esthetic aspects, and its possible relations with the fine arts? And might it not be possible so to educate the farmer that he should be conscious of these relationships, that his daily task should relate itself in his mind on the one hand to the great world of the physical and vital forces and on the other to the evolution of society and the trend of history and the making of a better world for children to be born in and men and women to live in?"

No one really need worry about the presence of

a number of eager practical-minded fellows in the university circle; "pure" science is stimulated by the problems of practical life as it, in turn, helps to resolve them. Robert Mayer, the discoverer of the law of the conservation of energy, was a doctor, and Joule, who first gave the mechanical equivalent of heat, a brewer. The plague of the potato disease and the example of the Irish famine directed De Bary's mind to the parasitic relations of fungus and host plant. Pasteur's scientific history, alone, illustrates the point. Indeed, mutuality is not only profitable, but indispensable to the progress of science in the modern world. As Whitehead puts it: "All the world over and at all times there have been practical men, absorbed in 'irreducible and stubborn facts': all the world over and at all times there have been men of philosophic temperament who have been absorbed in the weaving of general principles. It is this union of passionate interest in the detailed facts with equal devotion to abstract generalization which forms the novelty in our present society. . . . The main business of universities is to transmit this tradition as a widespread inheritance from generation to generation."

4.

But what is involved when we speak of a partnership in advancing the function of the university? For unless the phrase is, in these United States, something more than a phrase, agricultural educa-

tion might as well aspire to enter under the ægis of a gas company. In Great Britain and on the Continent the aim of the university is unequivocal, though it differs in the means of realization. First and always comes the advancement of scholarship. "The implication of this aim is twofold: that the training of the mind is all-important, and that the subject matter of the training is secondary. Seek and find the passion for accuracy and truth, and the patience and discipline that sustained and intensive study connote, and other things will be added unto you." [23]

Not every young man and woman who attends an English university is consumed by this zeal! In Oxford and Cambridge provision has always been made for the "Pass" student, who comes up for a pleasant four years, takes his work lightly, his sports keenly, his social engagements generously.[24] He is, in fact, in much the same situation as the American undergraduate.[25] But just as the Oxford and Cam-

[23] Edwin Deller, University of London. *Contemporary Review*, April, 1927.

[24] This is less true in 1929 than before the war. Pressure for admission to the two oldest universities tends to eliminate the Pass student.

[25] The point is made—perhaps somewhat inadvertently—in a review of Professor Reuter's *Populations*, by F. H. Hankins of Smith College. (*Quarterly Review of Economics*, December, 1924.) "Enough has been said to indicate the scope and character of this volume. It is only what it pretends to be—an elementary survey. It has a place as a college text and will no doubt be widely useful for that purpose. But this purpose has made it diffuse rather than scholarly, superficial rather than solid."

bridge Honours Schools do fix the mind of the undergraduate upon scholarship above all else, so, at a later stage and by different means, the graduate school of the American university aims at the advancement of knowledge and the training of men's minds. There is no reason, of course, why post-graduate work could not be preceded by "honours" preparation at the American college level. Such a régime is now foreshadowed at Swarthmore, Harvard and elsewhere. But, here and now, for the maintenance and stimulation of those purposes which together compose the University, we must look to the graduate school, first for an output of scholars, second for an output of knowledge, and lastly for an influence upon its own undergraduate department and upon the undergraduate departments of other institutions.

How, then, can the graduate school be advanced? The answer is the same for agriculture as it is for medicine, as it is for chemistry, as it is for mathematical physics. Research staff men must have more time at their command for experimental work —more uninterrupted time for thought—unbroken by calls for "service," police duties, too much undergraduate teaching and too many graduate students. They must be relieved of administrative responsibilities, taken off committees, protected from extension tours and kept clear of visiting delegations.[26]

[26] "We continue to live the life of people who are extremely occupied, without being able to accomplish anything interest-

When the pinch comes, they must have access to funds, either for assistance or for equipment. A few of these conditions depend upon money, the rest depend upon the administrative head of the institution, his clear-mindedness and his courage. They also depend upon the investigator himself; and many men, before they ask for more funds, time, and equipment to carry on research, would do well to use up to the hilt what they already have. But that is a digression.

In the second place, the fundamental sciences need to be developed. The present situation and some suggestions for its betterment will be discussed in the next two chapters, but a few obvious things may be set down here. No fruitful observation can be made or experimentally planned except out of a stimulated imagination; and that part of the imagination which is stimulated is the part which is dwelling consciously or unconsciously on certain working hypotheses of science. A discovery is not a discovery unless it conforms to and extends, or runs counter to, such hypotheses. A vivid apprehension of them, a sense of the limitations within which they hold good, a broad acquaintance with their manifestations in given media and under various conditions—these are essential to scientific discovery. They are, furthermore, imponderable influences which must sur-

ing. . . I have not yet discovered a way of defending ourselves against this frittering away of our time. . . Intellectually it is a question of life and death." (*Life of Pierre Curie:* by Madame Curie, p. 128.)

round the graduate student, and they will exist where there are suitable facilities for the pursuit of basic subjects coupled with the intellectual companionship of older men who are versed in them.

There is one further element which cannot be very well represented on paper, for it proceeds from a state of mind. That thing, which, for want of a better name, we call "pure science," is something beyond and different from the so-called sciences fundamental to agriculture. It is another name for disciplined curiosity. "It has no immediate practical purpose," says Carrel. "Its object is merely to find the truth and to understand the universe. Pure science classifies the typical knowledge of nature that we already possess. Beyond the apparent and often puzzling perplexity of phenomena, it detects the common element which underlies their seeming diversity. Then it can draw the generalizations which we call laws, and predict and reproduce the phenomena at will. The understanding of nature has always led to its control. Pure science which seeks knowledge in an absolutely disinterested way becomes, almost in spite of itself, the great power of this world. There is no other manner of obtaining a thorough knowledge of nature and of mastering it." [27]

So much from a man of medicine. One turns to an equal authority in the field of engineering, the Director of the Research Laboratories of the Gen-

[27] A. Carrel, "The Future of Medicine," 1926.

eral Electric Company. "Every engineer," he writes, "looks longingly at the properties he employs to see if they cannot be extended, and this leads to endless research of direct utility. But if pure science has any meaning, this is not it. A reason for saying so is that I fear we Americans may grow scientifically nearsighted. We may mistakenly think experimentation the mere recording or measuring of things. The mechanical operations may submerge the mental, and minds be shut in instead of opened out. Transportation was not advanced by breeding fast horses. Trimming sails did not lead to their displacement by steam. The telephone came without improving voices, and radio has come without improving wires. . . . We seem to get ahead by uncovering lightly covered creations rather than by stretching what we know further than it will go."

Science as the effort to purify, extend, and organize knowledge, if adopted as the one chief aim, will inure to agriculture in the future as it has in the past. So too, it has its place as an educational discipline, since the spirit and method of this endeavor will be reflected in the temper and quality of every student who comes within its orbit. In the hands of men who not only preach but daily practice correct observation, inference, verification and generalization, the ideals of the university will be safe. Let it not be thought that agricultural education by its nature precludes the cultivation of these qualities. Guidance which stimulates students to do these

things is scientific even if its subject is the eradication of weeds. Guidance which fails so to stimulate is unscientific even if it is concerned with the chemical composition of protoplasm.

There is nothing original or revolutionary about these views. They are given obeisance by the directing heads of many higher agricultural institutions. They are actually carried out, halfway, by some. They are the conscious goal of a persistent few. Where other conditions are favorable, these persistent few should be encouraged; for they are concerned with nourishing the cell which splits one day into distinguished and discovering minds.

5.

We have been speaking of the importance and future of the agricultural sciences at the graduate level. This type of advanced training is not visionary: the substance of it can already be found here and there; at Cornell, for example, in plant genetics; at Wisconsin in plant pathology; at Minnesota in entomology; at California in plant nutrition. Other illustrations could be given, not only from elsewhere, but from these very institutions. If they are still sporadic cases, it would be well to remember that the broad developments of instruction at the undergraduate level, experiment station research, and the extension service, all in their time were preceded by sporadic efforts. Agricultural education has been on the march. It is hard to believe, in the face of those

indications, that the march is over. And it is hard to believe that the next line of advance is not in the graduate school. Indeed, one institution alone could give the command.

In such an atmosphere, undergraduate instruction would get a new impetus and character. Just as the Johns Hopkins University found it necessary to create a college to meet its high requirements, so, almost unavoidably the influence of such a graduate school would affect the undergraduate curriculum. And though more basic scientific study and more experimental practice would chiefly benefit prospective teachers and research workers in agricultural science, it is submitted that such a development would help rather than handicap the student who plans to return to the farm. For he has as definite a need of training in the art of inductive science as the man in his laboratory. If he were to acquire it he would have that power which any educated man in his profession most prizes, the power of "making his mind a ready servant to the will." It takes very little imagination to visualize a farmer so trained, back at his work, equipped with simple instruments of scientific observation, using the winter evenings to explore the field that Pasteur, Davy, Liebig, Lavoisier and Boussingault cultivated, maintaining experimental plots of his own, in touch with the latest scientific workers and measuring his results with theirs as he collaborates with them at a distance. His time might be interrupted, his field of

investigation might be somewhat restricted, but his spirit and method could be unimpeachable. Even though he should not possess what Morris Cohen calls an architectonic mind, he could be sure of laying bricks in the edifice of science.[28]

If this seems too visionary, let the fantasy lie where it falls. Some day, perhaps under a program of large-scale farming operations, there will be private technical laboratories, there will be a scientific division of the establishment like the research division of a great industrial concern. Meanwhile any farmer, quickened by four years of experience in the scientific method, can join if he likes in the common quest for truth and hasten the increase of knowledge.[29]

[28] "With only a high-school education, Thomas Mixesell carried on the most complete, extensive and accurate phenological observations ever made, in conjunction with his regular farm operations. . . In addition to records of rainfall and temperature, he kept records for 150 species of plants for 30 years, recording every phase of plant growth from the time the buds started until the plant was divested of leaves and scarcely a single observation was missing. Similar records were kept of the times of migration, dates of nesting and other life incidents for a large variety of birds." (*Science*, February 13, 1925, p. 175.)

[29] The following extract is taken from a private letter under date of June 14, 1927: "Sometime ago, I believe, I wrote you that I was combining practical 'dirt' farming with some very interesting scientific and educational studies. . . I have long been interested in the American revival of a very ancient form of building construction, *pise de terre* . . . and am looking forward to a thoro examination of various ancient structures in Spain and France, and methods employed, before building extensively myself, and publishing my findings.

"Then I have been working on certain problems in connection with my own special line, alfalfa growing, especially in the mat-

So far as the farmer is concerned, let him seek the college rather than the college seek him as such. The mountain has gone to Mohammed for more than half a century: let Mohammed come to the mountain for a while. And let him come to get no dogmatic instruction in practical skills which is essentially four years of resident extension, but to get that hard training in experimental science which will turn him out a better educated man as well as a more confident craftsman. There is every reason not to exclude the prospective farmer; but the highest type of scholarship should be required of him. He will not suffer from it. While, per contra, as things now are, to adulterate the scientific work of the institution in order to meet the old-fashioned superficial stipulations for agricultural training, is to fall between two stools and to sit upon neither.

6.

The physical and biological sciences have slowly won eminence because their discoveries have con-

ter of curing. There are some rather obscure fermentations which take place, as well as autolytic processes. In order to clear this matter off the boards, I am looking forward to a stay in the laboratory of Doctor Robert Chodat, at Geneva.

"The third line, education, is of more general interest and application. I have been working with rural school problems, especially rural secondary schools, and primarily with the great question of curriculum revision to bring the schools into a more constructive relationship with the communities. . . But I feel now that I should study very carefully the methods and organization practiced in Denmark, where, apparently, there have been such remarkable results. . . ."

tributed to a better understanding of the world in which we live. Their method supplies a universal logic capable of extension far beyond the field of the natural sciences. Their spirit has been objective and impersonal. When their lore has been translated into terms of medicine and industry their practical use has been made evident and this very usefulness has accelerated their recognition and promotion. Medicine and industry, turning to the basic sciences for help, have assisted them in the best possible way —by asking hard questions. Agricultural science lays claim to the same recognition. It includes the body of scientific knowledge and method directed to the solution of the problems of plant and animal biology. The needs of the agricultural industry have stimulated its development and have given it direction. Agricultural science, too, has put questions to physics and chemistry and has received help. It needs more help now, and physics and chemistry need more of its questions.

But why, one may ask, if all these subjects are eventually reducible to physics, chemistry, biology, and mathematics, is it necessary to conserve or cultivate another category which is pleased to call itself "agricultural science"? Why should not the agricultural industry confidently wait upon the work of a few great endowed institutions or institutes in the basic fields? The question is fair, but agriculture has had to resolve it in the negative. The decision has come from the pressure of need. Doubtless in

the course of time discoveries of great value to agriculture will emerge from the general laboratories as they have in the past, but meanwhile neither health nor industry nor agriculture can wait. An effective treatment for pernicious anemia was discovered without determination and isolation of the effective substance. Rickets was prevented and cured by empirical treatments with both sunlight and cod-liver oil long before vitamins were heard of. Medical men did not wait. Their requirements were so pressing that they staked out a claim of their own, did much empirical work within it, found the need of basic science as a better background for their own research, cultivated it in a not unsatisfactory way, and established themselves. First medicine, next industry, finally agriculture, realizing that their own somewhat specialized research needed broadening, turned to the university, not to be absorbed but to enter into partnership with the university idea. Beginnings have been made in agricultural science. They hold out promise for an improved industry and a major advance in education.

CHAPTER VI

THE BOTANICAL SCIENCES—PLANT PHYSIOLOGY

1.

Among the sciences fundamental to agriculture those which fall under the head of botany are further advanced than the zoölogical group except, of course, where the latter appear in medicine. A survey of plant and animal pathology, physiology and genetics would support this view. One might reason from this premise that since botanical studies are now nearer to the university level they should be given precedence in any stratagem to attain it. But, avoiding comparisons, we will do better if we merely examine the situation in the plant sciences to-day, the stages through which they have come, and the line of their probable development. Such a review may suggest whether they comprise a field of knowledge appropriate to the University.

2.

If the reader, like the author, is a layman, he will feel the need of help at just this point. The author has found it in the statement which follows, and he offers it, by permission, in its entirety; for there

seems to be no briefer way of saying the essential things:

"All of natural science is observational. During the earlier stages of its development it concerned itself with describing and comparing the more obvious, complex and grosser aggregates of matter and units of energy. Through the analysis of large volumes of descriptive data it succeeded in establishing many valid correlations between groups of phenomena. Subsequent search for actual causal relationships has led to the investigation of smaller and less complex aggregates or units; and natural science has resolved itself into a series of subdivisions, each of which deals with particular groups of phenomena and has developed its own specific observational technique. Thus, in the biological field, morphology has passed successively from a consideration of external form (taxonomy and systematic biology) to the study of gross internal structure (anatomy and histology) and finally to the description of the visible structure of the protoplast (cytology). Similarly chemistry has progressed from the investigation of compounds to molecules, atoms and electrons.

"Physics and chemistry in passing from the investigation of visible to invisible units were forced to develop highly refined and exact quantitative experimental methods. In other words, they have substituted an intensive analytical technique for an extensive observational one. Only in the study of heredity

has biology (genetics) succeeded in originating quantitative experimental methods which are comparable to those of physics and chemistry. Most of the biological sciences are still concerned with the investigation of visible phenomena and with the establishment of correlations through cumulative circumstantial evidence; the transition from gross morphology to cytology has involved the use of the microscope, but no radical change in the point of view of the investigator.

"It should be emphasized in this connection that plants and animals are so numerous and diversified, and vital phenomena are so complex and so extraordinarily variable, that all of the biological sciences still have important rôles to play in the future. The compilation, codification and analysis of descriptive data, and the formulation of valid correlation is not only of great practical significance in the development of the biological arts, but is indispensable in the visualization and definition of those fundamental problems which biology seeks to solve. Nor should it be inferred that this work when well done is of an inferior intellectual quality. The descriptive method requires capabilities and disciplines which are by no means inferior to those used in the exact sciences. In fact the successful employment of cumulative circumstantial evidence—e.g., Darwin and the Theory of Evolution—demands qualities which are rarer and often more finely discriminating than those employed in the exact

sciences. Thus, although most biological research and experimentation, except when concerned with the simpler physico-chemical reactions in organisms, is essentially descriptive and empirical from the point of view of modern physics and chemistry, it does not follow that it is inferior or less useful.

"It is evident accordingly that there are two distinct methods of investigating complex biological phenomena; one the extensive observational method of the descriptive sciences and the other the intensive analytical method of the basic experimental sciences. The former sciences work to establish valid correlations between visible aggregates of variables. The later sciences aim to resolve these aggregates into their constituent variables and to study these individual variables under accurately controlled experimental conditions. Each line of attack has distinct advantages and limitations, and each requires particular abilities and disciplines and a specific psychological outlook upon the part of the investigator. On the one hand, the descriptive sciences are able to make rapid progress in the study of the visible forms and activities of living matter and in establishing correlations between them, but they are handicapped in determining the underlying fundamental whys and wherefores. On the other hand, the accumulation of reliable data through the methods of the basic experimental sciences is a tedious and time-consuming process and no valid

generalizations are possible until a certain essential total of experimental evidence is accumulated.

"Both lines of attack appear to be essential in the ultimate solution of the fundamental problems of biology. The descriptive sciences are able to formulate and roughly define these problems, but they are dependent upon the basic experimental sciences for the necessary means of accurately analyzing them. Although physics and chemistry have developed methods for investigating certain of the simpler physico-chemical reactions in plants, they have not succeeded as yet in perfecting adequate techniques for analyzing the more complex vital phenomena. Until such techniques are available, attempts on the part of biologists to solve highly complex and variable biological problems through the use of quantitative experimental methods are of doubtful value. Furthermore, there is a serious question as to whether the methods of the descriptive and of the exact sciences can be combined successfully in the hands of a single investigator. Occasionally an exceptional individual may be able to master modern physics and chemistry and one or more of the descriptive sciences, but most investigators are unable to do so and tend to become more or less superficial in all fields. Thus, much of the so-called modern fundamental biological research . . . is unfortunately an aimless puttering with quantitative methods and is unproductive from the point of view both of the

descriptive sciences and of the basic experimental ones. The phenomena to be investigated are so complex and variable that, in many cases at least, they can be solved only through the active coöperation of a group of physical, chemical and biological experts.

"The utilization of scientific data in the arts is dependent (1) upon the stage of development of the art, (2) upon the stage of development of the sciences and (3) upon economic factors. The descriptive method coupled with simple empirical experimentation is of maximum service during the pioneer stages of a biological art, since it affords the most economical and rapid means of establishing such correlations between dominant factors or between groups of phenomena as are of practical significance. Eventually this line of attack tends to exhaust its most promising possibilities and during the later stages of the development of the art there is an increasing necessity for truly fundamental experimental research." [80]

Plant physiology deals with all the processes and changes that take place in plants, as human physiology deals with processes and changes in human beings. It seeks to understand the relations between these processes and the effect of the environment on them: it tries to find out how they are altered as the

[80] *A report to the Special Committee of the National Academy on Forestry Problems in the United States.* I. W. Bailey and H. W. Spoehr (June, 1927). Quoted from manuscript.

plant matures and until it breaks up. Physiology is the dynamic aspect of botany.

The subject-matter is difficult. Comparatively little trustworthy research has appeared, and until any large province of inquiry has been broken up into smaller provinces, it is, by the mere fact of its size, formidable and discouraging. What is the nature of immunity to disease? We are a long way from knowing. What criteria can be set up to recognize it when it exists? What are its underlying causes, preconditions? Or again: what is the nature of the plant's power to adapt itself to non-living environmental circumstances such as heat, cold, drought, acid or alkali in the soil? What really does happen in the most important process in nature, the manufacture of carbohydrate from water and carbon dioxide by green leaves in sunlight? Expressed in physical and chemical terms, what takes place in the process whereby food passes from one part of the plant to another, when the plant gives off water or when it breathes?

Then, too, the plant has an elaborate environment, living and non-living. The equation between them is constantly rewriting itself; for the relationship between the internal plant processes and other processes which are going on within effective distance is never twice the same. This constant flux not only makes observation and experiment difficult, but without elaborate controls it is impossible for an observation to be verified or an experiment to be

repeated. Scientific "findings" made in these circumstances, when inadequately controlled, do not amount to much. They may be valid records of what once happened *under given conditions,* but since the conditions, the equations, the relationships are so everlastingly variable in their permutations and combinations, those that are "given" once are never given by nature again. With these disabilities uncontrolled, our scientific findings, though fact and thereby a small insignificant law unto themselves, do not suggest, confirm or disprove a general law.

But perhaps the greatest difficulty of all is not with the science but with the scientists. If controls are important for quantitative determinations, so is collaboration. It is not enough for your physiologist to know some physics and chemistry—physicists and chemists must work with him, or, if you please, he must work with them. The association is difficult to bring about, for these Modernists and Fundamentalists of science are inclined to stand each other off at arm's length, the one believing that all matter can be described in non-living elements, the other believing with Claude Bernard that "there is an arrangement in the living being, a kind of regulated activity, which must never be neglected, because it is the most striking characteristic of human beings." Yet the rapprochement is not far off, for the physiologist, these days, is ready with Jacques Loeb to "adopt a deterministic attitude as soon as he steps into his

laboratory." Indeed, whatever his ultimate reservations, he understands that this attitude is the basis of rational experimentation.

Therefore, under the ægis of plant physiology, and under some suitable scheme, title or directorship, a vigorous collaboration between chemist, physicist and biologist might be launched. For the science is pure and yet not pure, applied and yet not applied, all chemistry and physics, yet perhaps not quite. It might well be the Garden of Eden of scholarship, instead of the No-Man's Land.

3.

As an educational discipline, it meets the severest requirements of the idea of the university; it inculcates a knowledge of life external to the student, and an appreciation of the amazing arrangements of nature; it illustrates at every turn the interdependence of the various categories of knowledge; it has no anthropomorphic bias.

As it rests on physics and chemistry, so the other botanical sciences rest on it. The soil group, though in one aspect independent, is connected on the functional side with physiology, and derives most of its importance from the contribution it can make to the knowledge of plant nutrition and growth. Entomology, *selbständig* on the descriptive side, strives to discover how the life processes and life cycles of insects affect the well-being of plants. Pathology, through its immediacy, its accomplish-

ments and its virility, has carved out for itself a separate province; nevertheless, of all the related subjects, it must look more than any other to physiology for its direction and its base. For, as a matter of intellectual procedure and of clinical practice, the investigator can identify diseases and hunt for their cure only in so far as he keeps before him a picture clear in essentials, yet shadowy enough to cover individual variations, of the plant in health. Genetics, though it makes no great contribution to physiology, keeps presenting problems and is itself becoming largely the physiology of developmental control. Ecology is less a subject than a name to include the study of all natural external conditions, not otherwise ticketed, which affect plant growth. Such unity as it has is derived from this orientation toward plant life: if that were removed it would fall into its discrete parts. Yet, as Dr. Livingston has said, "this vigorous child has introduced into the house of botany a sympathy for the problems of agriculture and forestry that was not present before."

Lastly, plant physiology has its practical applications to agronomy, horticulture and silviculture. To be sure, it has no nostrums, and (what is its distinction) it cannot promise this result or that. But it can assert, quietly sure of its strength, that without an expanding and deepening physiology, progress in the practice of agricultural production will come to a blank wall.

4.

The difficulties and the opportunities of this field have been set out at perhaps unwarrantable length. It seems to be one strategic point for the development of fundamental agricultural science at a university, and what is different, at the university level. A small group of qualified men, representing the three main natural sciences, freed from undergraduate teaching, relieved of responsibility for work in an experiment station, and unaccountable to the extension service might, in their own research, and by training a handful of promising successors, "light such a candle by God's grace, Master Ridley, as shall not be put out."

CHAPTER VII

OBSERVATIONS ON SCIENCE AND RESEARCH IN THE AGRICULTURAL COLLEGES

1.

The so-called "agricultural colleges" may be divided into two types:

(A) Those which are a part of universities: as at Cornell, Wisconsin, Minnesota, California.

(B) Those located by themselves as separate agricultural, or agricultural and engineering, institutions: as in Michigan, Kansas, North Carolina.

The division into two types is everywhere recognized.

Generally speaking, in institutions of type A, the trend in the past and at present is toward the university level of science and education. Certainly in the four examples given above, great progress toward this goal has been made in the past fifteen years. In the institutions of type B, emphasis has been laid upon the vocational function of the institution. Yet the division is not quite so clear as it might be: for all the colleges of type A, in dealing with the legislature, lay stress upon their farmer-training activities, while cultivating science under handicaps; and many

of the colleges of type B, thanks to the wisdom (if not the courage) of their administrators, permit certain of their men, pretty much under cover, to do sound and valuable scientific work. These instances, however, are rare, and they are at variance with the popular idea of the institution's business; so that, in general, the colleges of type B are vocational and extension-minded, economic in their objectives, and local in their usefulness. What they are now doing along broad scientific lines may be regarded as an indication that with the proper kind of encouragement they might turn more definitely in this direction.

2.

In most of the colleges of type A there are certain beliefs held by their scientific men:

That research of a fundamental character on long-time problems of scientific significance is a condition of progress in teaching, research and extension.

That it is indispensable to the kind of graduate training which is demanded for important agricultural posts.

That in the state institutions of university type, work of this sort has been done in the past, and is being done at present.

That while the training of their "scientific men" doubtless could and should be better, the chief limitation on their development and achievement lies in too much undergraduate teaching, the demands of

the extension service on their time, administrative duties, and the need for doing physical work which could just as well be done by a low-salaried assistant. Above all, since funds for support of the institutions' work and their own researches come from the legislature, they find themselves under pressure to handle short-term "practical" problems and produce quick results. Even when pressure is not exerted, its shadow is in the background.

They feel, too, that the present situation is critical from the *educational* point of view. More and better work must be done in the sciences fundamental to agriculture if the institutions of type A are to achieve full university stature. Failing to go forward, they must become in fact vocational institutions with instruction chiefly by rule and rote and with "research" represented mainly by empirical stabs. From the *agricultural* point of view: important developments are taking place in biology, following upon recent progress in physics and chemistry. Even if agricultural institutions are to act merely as transformers through which scientific discoveries made elsewhere can be broadly and intelligently applied, they should nevertheless be firmly grounded on the basic sciences. But if they are to participate as they can, do and ought, in original scientific work of high grade, these foundations are more essential still. The field of agricultural science requires explorations not only by institutions of "pure"

science but also by those which are pointed in a broad way toward the implications of agriculture for human needs.

3.

If then, it is important, from the standpoint of agriculture and from the standpoint of education, that at least the institutions of type A should now press forward to the best university level in science; and if the attainment of this objective depends upon the quality of research and graduate teaching, then the question follows: What can be done to improve their quality?

Let us look at some aspects of the present situation. First (and we are speaking of the agricultural divisions of universities), the average directing head, the dean, though in other respects well qualified for the duties of his many-sided office, has not the scholastic training of his "opposites" in other divisions. Of twenty-four deans of agriculture, ten have never gone beyond the ordinary undergraduate course, ten have taken an extra year for the master's degree, but only four out of twenty-four have the doctorate. In most of the institutions of this type the dean is also director of the experiment station. In the few cases where this is not so, the scientific training of the director has been less than one would expect. Out of six such special officers, three have stopped at the bachelor's degree, two have gone on to

the master's, and only one of them has attained the doctorate.[81]

No special importance attaches either to the final degree itself or the discipline which leads to it; but it is the best we have, and in academic circles it seems to be an objective of those who profess to be scholars. The man who does not take his doctorate may be considered, under the prevailing view, as lacking some appreciation of the place of sheer scholarship in the scheme of agricultural education. But having made this point, we should avoid laying too much stress on it. Younger men coming into the top posts, these days, are better prepared. What is more, the duties of a dean (and to a less extent those of a director) are many and diverse. In order to estimate the fitness of any man for one of these two offices, or both, his individual qualifications for a curiously compounded task must be considered. Even in the realm of scholarship, it would be well to ask about his practice toward research, the freedom he allows his scientific staff and the encouragement he gives them, rather than to come to any conclusion on the bare details of his academic record.

The training of the heads of scientific departments in agriculture is, on the formal side, much like that of their colleagues in "arts and sciences." In the

[81] As of May, 1927. Sources of information: Who's Who in America, RUS and American Men of Science. Care has been taken in preparing these figures, but the uncertainty whether these three sources are complete, and changes in personnel make for possible errors in detail.

older departments, those of chemistry, physics and mathematics, the heads have had a slightly longer period of postgraduate training than their opposites in biology, and they have taken over the direction of their departments somewhat later in age and in experience. As biology stands toward these three more exact and better established departments, so plant physiology, pathology, genetics, entomology and the soil sciences stand toward biology itself. The newer the subjects, the less the training and the earlier the headship. But the difference is one of degree, not of kind: it is explained by the growth of biology itself and the creation of new departments in the biology of agriculture which have had to be filled with more than ideal rapidity. To-day, both in biology and in the fundamental plant sciences, men who become heads of departments are at no disadvantage either in the extent of their formal training or in the length of their administrative probation.

It has just been said that men in agriculture "arrive" somewhat later in life and experience than they used to. But this is not all gain. It is good, of course, in that responsibilities do not fall upon too young shoulders. But since, in many state universities, the privilege of a sabbatical year cannot be enjoyed until after six or seven years of service, after one has attained professional rank, a man is pretty successfully precluded from the chance of preparing himself for a responsible post until after he has got it. Sometimes he is allowed to take his

doctor's degree, in a fashion, while he teaches, but this is thin gruel. A man who is approaching a professorship in agricultural science needs more training than is involved in a quasi-doctorate. No doubt it is too much to ask that the recreational needs of the staff be considered in this fanatically hard working society of ours, but any promising research man who requires a period of advanced study away from his own institution, and is intellectually hungry for it, should be helped on his way, with all the good will in the world, and with every generous provision that an institution can arrange for him by fair means or foul.

4.

So much for some of the limitations on the training of the directing heads in agriculture and their scientific staffs. They are far less than they used to be, and the few remaining disabilities are disappearing year by year. The same generalization is true of the undergraduate curriculum. The tendency is to reduce if not to eliminate courses in practical agricultural skills; the intellectual discipline is severer than ever before. In fact, to repeat our quotation from Doctor East of Harvard, and to apply it in a new connection:

"The work given in the institutions supported by the wealthier states, such as New York, Wisconsin, Pennsylvania, Ohio, Illinois, Michigan, Minnesota and California, compares favorably with that in other first-class colleges."

The material which presents itself from these agricultural colleges for postgraduate training, is hardly inferior, if at all, to that which comes up from the endowed institutions. One hears the rather subtle distinction that "the latter are better *trained*, but the former are better *men*," the inference being that if the intellectual discipline of the undergraduate from the agricultural college lacks something in content, it has nevertheless managed to confer a certain quality—whether of insight or purpose—which offsets the loss.

There is no need to go over the ground which Doctor East traversed in coming to his conclusion. It may be accepted. Indeed, an independent study credits at least one of the university agricultural departments with many more "cultural" and general science units than East discovered. It might be well, however, to call attention to a recent development. The University of Minnesota, within the College of Agriculture, is providing a course in Agricultural Science for the undergraduate student. The Freshman year is made up of Botany, Chemistry, Mathematics and English. In the Sophomore year students are required to take Biology, Chemistry, Bacteriology, English, German, Logic and Public Speaking. In the Junior and Senior years, the student's adviser helps him choose his studies—the only requirement being that he must have a major of from 24 to 36 credits in some field of agricultural science, and a minor of from 18 to 21 credits in another. The

course is designed primarily to train students for postgraduate work, and to lay the foundation for careers in agricultural colleges and experiment stations; and a study is to be made of the individual student in order to help him decide which branch of science he is best qualified to enter. It sounds like a well-considered and uncompromising plan and its outcome will be watched with interest.

There is no special reason for presenting comparative tables of entrance requirements. Things have moved ahead at a good pace since 1896, when a Committee of the Land-Grant Colleges could only agree upon Physical Geography, United States History, Algebra through quadratics, Arithmetic through the metric system, and English grammar with composition. To-day the requirements for admission to agriculture are practically identical with those demanded by the college of arts and sciences. But, unfortunately, that is not quite the whole story. At a moment when standards of admission were just about where they ought to be, Smith-Hughes schools for vocational training in agriculture were established. At present, in preparing students both for practical farm work and for college, they require an unprecedented amount of vocational study and practice. The purposes embodied in the Smith-Hughes Act and the work done under it are commendable; excellent instruction in general subjects and in the farming art is given to the youngster who cannot go on to college. But the conviction persists that when

a school makes those of its pupils who are headed for college spend many instructional hours in farm manipulations, it is working an injustice. The college that accepts freshmen, so unprepared, sets its own clock back. The situation is controversial. Minnesota, with far more courage than it took to establish her undergraduate course in agricultural science, has refused to accept students from Smith-Hughes schools who present more than four hours of vocational high school work. Wisconsin has followed the same policy. Cornell is between the upper and the nether millstone, and seems to be aware of it. Other institutions are in precisely the same posture, without that uncomfortable awareness. Yet one thing is clear. The universities cannot give ground in the matter of their standards of admission, and at the same time expect to continue advancing toward the university level in agriculture. Or if they are forced by legislation to make a concession, they may be able to salvage their ideals by setting up two parallel courses—Pass and Honours, in character, if not in name—one for continuing vocational instruction, the other for fostering creative minds.

In addition to these limitations on the training of the research staff and on the quality and previous education of the "material" that comes up to them at the graduate level, reasons have already been given why research men are handicapped in their scientific work. Duties of all sorts in undergraduate teaching, administration and extension put scholarship in

jeopardy. We know well enough that elementary lectures did not hurt Faraday, Huxley, Agassiz, Bayliss; instead they were helped thereby to elucidate their own theories. A few first-rate scientific men have been hard-working administrators; and many of them have found suggestions and checks for their investigations in the material or questions brought in from the field extension science. But the value of these external influences varies with the individual; and it is the part of a wise directing head to temper the wind to his research staff, man by man. As time goes on provision is more and more made to relieve the right men of distracting tasks, and as a result a larger amount of sound and suggestive scientific work appears in print.

Some funds are available for research of long-range character, regardless of its applications.[32] Any administrator, if he made an issue of it, could probably get more money from the legislature for this purpose, either as an outright annual appropriation, or as a conditional appropriation to offset the proceeds of an endowment secured from private sources. The technique is familiar enough; state legislatures give generously to offset the Federal appropriations of the Hatch and Adams Acts: there would appear to be no reason why they could not give, in the same fashion, to match the interest on private endow-

[32] The University of Wisconsin receives an annual legislative grant of $30,000 for this purpose, and in the 1927 appropriation bill $50,000 was asked for.

ments. After all, in a little time, the major part of the responsibility for higher education will have been transferred to the shoulders of the state universities. Even to-day, in spite of all the time spent in "service" they are warmly contesting the leadership of the endowed institutions in the advancement of knowledge.

5.

Graduate work in the agricultural sciences has been criticized in some quarters because students during this period have accepted industrial fellowships or have been used as assistants in experiment station projects. Such a criticism should be advanced with caution. There are fellowships, supported by agricultural industries, which are free in their terms, and there are plenty of station projects broadly enough conceived to afford any student ideal experience in advanced experimental work. The criticism should likewise be tempered with understanding. Very few of the men who take graduate work in agricultural science have the means to spend three years as they would like; and this fact has to be taken into the reckoning by the one who directs their studies. In most cases it is a question of no postgraduate training at all, or subsidized training under somewhat less than ideal conditions. The dangers inherent in accepting an industrial fellowship are obvious: they can only be guarded against if institutions refuse to accept industrial funds which

are in any way restricted in their use. That men likewise are used, and occasionally abused, in connection with station projects, is well known. It is an economy to engage their services, and the station's output is thereby increased, but where this employment makes a competent "*Diener*" out of a promising scientist, we are in the vicinity of a sin against the Holy Ghost. The essence of the transgression will be recognized by many academic men who never heard of an experiment station.

These two types of graduate work—under industrial fellowships and in station projects—are chiefly interesting, not because they are sometimes unproductive, sometimes even perverted, but because they throw light upon a condition. For many years past, now, and probably for many years to come, the agricultural student will be found to be poorer than other young men who are headed for the law, engineering, and other professions. It takes courage, with the bachelor's degree in hand, to face three more years with nothing in your pocket. Here and there a few unrestricted fellowships are to be found and they are eagerly sought after. Minnesota, for example, has three of the value of $500 each: they are awarded after competition. During a period of five years, 43, 45, 32, 32, and 57 men, respectively, offered themselves as candidates. In 1926, a low year, there were 32 contestants drawn from various institutions. Three were chosen and the

rest had to be dropped.[38] Small though the amount of each fellowship is, and limited though they are in number, the donor, if he is still living, must take satisfaction in the productive use to which his money has been put.

On the whole then, there seems to be no intrinsic reason why graduate work in agriculture in state universities should not stand on exactly the same footing as that of the other older disciplines. The gap between them in most of these institutions is negligible and what little remains is closing rapidly. With this reassurance on the ground of quality, we might turn to consider the way in which good scientific work (or indeed inferior scientific work), radiates from certain vigorous centers. A chart is appended, showing how the New York State College of Agriculture at Cornell reaches out to its students and to the people, through the teachers whom it trains for secondary positions, through the newspapers of the state, through boys' clubs and girls' clubs, home demonstration leaders and county agents. There are fifty-four counties with agents—and with one exception these posts are held by college-trained men. One need not expound this chart: though it would be well to add that the same influence is exerted

[38] "Thirteen of these men already had the master's degree, and thirteen (this includes some with only the B.S. degree) had qualifications to go on with graduate work with almost a certainty of success. In many cases, the difference between such a $500 stipend and nothing, means the difference between going ahead with graduate work and the utter impossibility of such an attempt." (Extract from private letter.)

in much the same way by other state institutions, and to call attention to the fact that, within any given state, the quality of agricultural science will affect, for better or for worse, the furthest corners of the commonwealth. (See appendix for charts.)

That is enough of a responsibility, but state universities are by no means coextensive with state boundaries in their influence. A second chart shows the countries and states from which 273 students have come to take postgraduate work in agriculture at the University of Minnesota since 1906 [84] and the even greater number of states and foreign countries where these holders of advanced degrees are now working. They are drawn from 29 states and 8 countries, they have gone out to 39 states and 8 countries. Nor is this an exceptional case; Cornell and Wisconsin, perhaps others, would show an even wider net and a wider distribution.

Indeed, it might be allowable, in the same illustrative way, to speak of one department, still vigorous under the leadership of the man who made it great—the Department of Plant Pathology at the University of Wisconsin. In a state institution and not unmindful of the special economic interests of Wisconsin, it has nevertheless made a contribution to the development of one important plant science the world over. A third chart shows where the inspiration of L. R. Jones is multiplied through the men and women who have taken graduate work

[84] 264 of them since 1911.

under his direction. It is submitted as evidence of the wide influence of outstanding scholarship at the graduate level in agriculture. It would have to be included even at the cost of criticism: it is therefore reassuring to realize that no one in the whole company of scientists is likely to take exception to this somewhat personal reference.

Those of us who are interested in higher agricultural education from the outside, as it were, are hardly aware of its broad influence. In particular, while we know and are likely to emphasize the debt which it owes to certain endowed institutions for the graduate training they have given to some of the best men in agricultural science, we perhaps do not realize that there is a debt on both sides. The flow of first-rate men has by no means been merely from the departments of pure science to the "applied" field of agriculture. Doctor E. W. East, Professor of Plant Genetics at Harvard, received his doctor's degree in the Department of Agronomy at the University of Illinois. He later spent some years as a worker in plant breeding at the Connecticut Agricultural Experiment Station before he was called to his present post at Harvard. Professor Raymond Pearl, of Johns Hopkins University, established a reputation in animal genetics during his years of service at the Maine Agricultural Experiment Station. Doctor T. B. Osborne of Yale, sometimes called the father of the modern science of nutrition, worked and still does work at the New Haven Agri-

cultural Experiment Station. Here he had as associates and students Doctor Mendel of Yale and Doctor McCollum of Johns Hopkins. Before going to his present position, Doctor McCollum was for several years a member of the Department of Agricultural Chemistry of the University of Wisconsin. The late Doctor Erwin F. Smith, of the Laboratory of Plant Pathology of the United States Department of Agriculture, produced in his own laboratories work on plant cancer which has been recognized by medical science as a valuable contribution to the study of human cancer. Chicago University has called to its laboratory of plant physiology in the Department of Botany, Doctor E. J. Kraus, recently engaged in applied biology at Wisconsin, formerly of the Oregon Agricultural College and Experiment Station.

6.

There is one inference which should not be drawn from this exposition. Merely because the scientific situation in the agricultural divisions of state universities has been under review (it is the subject of this chapter) there is no intention of minimizing the place which leading endowed institutions with their traditions and with their trained staffs have occupied and will occupy in the future. Chicago, the Bussey Institution, Yale, Columbia and Johns Hopkins, for example, have for years challenged the best men in the agricultural colleges by the high

standards of scientific work which they have maintained. East and his colleagues at Harvard, the Chicago group, Mendel and Osborne at Yale, Morgan and Harper at Columbia and Livingston in Baltimore, have been and are valuable sources of first-rate men for the institutions of agricultural science. There are others. And it is a question not pertinent to this report whether, viewed with an all-seeing eye and equipped with balances to weigh the imponderables, agricultural science on the graduate level could be best advanced through the indirect influence of the endowed universities or such an agency as the Boyce Thompson Institute for Plant Research, or through the direct influence of the agricultural sciences in some one of the leading state universities.

But one thing is certain—that there is no reason in the nature of things why agricultural research of the highest order, and graduate training second to none, cannot be achieved and maintained in one or more of the state universities. This, in itself, comparisons apart, is worth doing. And there are these further final comments: that all the endowed institutions and institutes in the world may train men as fast and as well as they can, but these men cannot be expected to do first-rate scientific work unless, in the institutions to which they go, such work is highly prized and relentlessly promoted; that the quality of graduate work in the state universities will not be its ultimate best until the quality of undergradu-

ate work is elevated, and improvement at this level must be wrought at home. Lastly, the agricultural colleges have been and still are a group by themselves. Their future will be of their own making. The influence of their elder brethren on their development is important, but it is slow and indirect. On the other hand, the example set by one of the Land-Grant Colleges upon the others, in any field or at any level, is quick and strong.

These considerations throw responsibility for the development of fundamental science and research in agriculture, for the betterment of graduate training, and for the achievement of all that is implied in the elusive word "university," squarely on the shoulders of the state institutions. If it is a great responsibility, it is also a great opportunity.

CHAPTER VIII

CONCLUSION

"Truth," wrote the late Sir William Bayliss, "is more likely to come out of error, if this is clear and definite, than out of confusion, and my experience teaches me that it is better to hold a well-understood and intelligible opinion, even if it should turn out to be wrong, than to be content with a muddle-headed mixture of conflicting views, sometimes called impartiality, and often no better than no opinion at all."

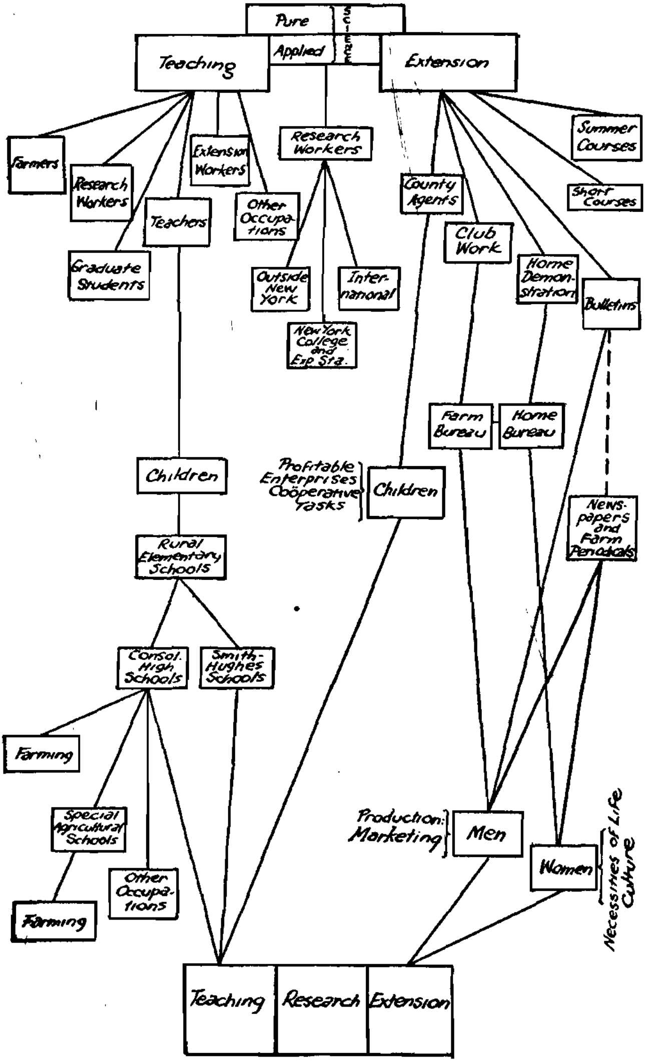
. . . . . .

Here, then, is the gist of this book, as briefly and as clearly as it can be put. The agricultural college is the nucleus of agricultural education. Its chief duty, to which all others should be subordinated, is to prepare men and women for responsible posts in agricultural research, teaching and extension. The most important of these posts require graduate training. Agriculture, therefore, must maintain its higher work at the university level. One promising way to insure this is by promoting fundamental research in the field of the natural sciences and particularly in those that deal with plants. The

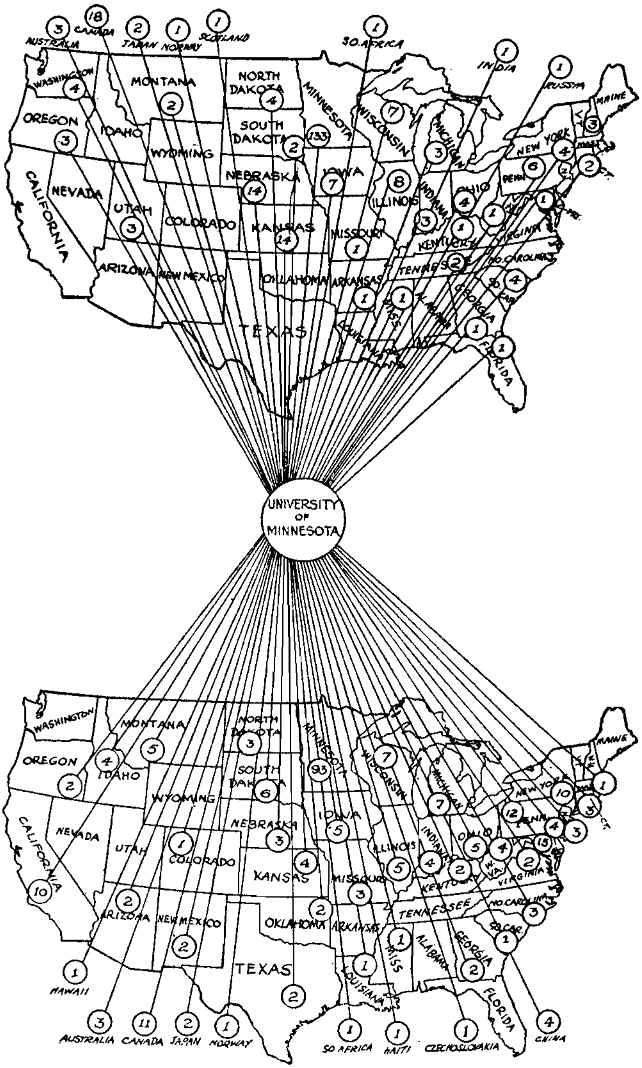
basic science of that group is physiology, which is difficult and still undeveloped. It is a suitable university discipline. Its complexity demands the harmonious coöperation of chemists, physicists and biologists in long research without pressure for practical results. Out of work conducted in this spirit, graduate training of excellent character should take a clearer form.

The author believes that there are certain institutions of the university type with a duty to promote agriculture, where the directing head is keenly disposed to further the botanical sciences, where there is already a group of able men, where the provision now made for research is an indication of the interest of the administration, and where there are signs of coöperation between the biological sciences on the one hand and physics and chemistry on the other. In such institutions a development of plant physiology and adjacent fields at the highest educational level would benefit science, stimulate the institution and provide an experiment and demonstration of significance for the whole group of Land-Grant Colleges.

APPENDIX



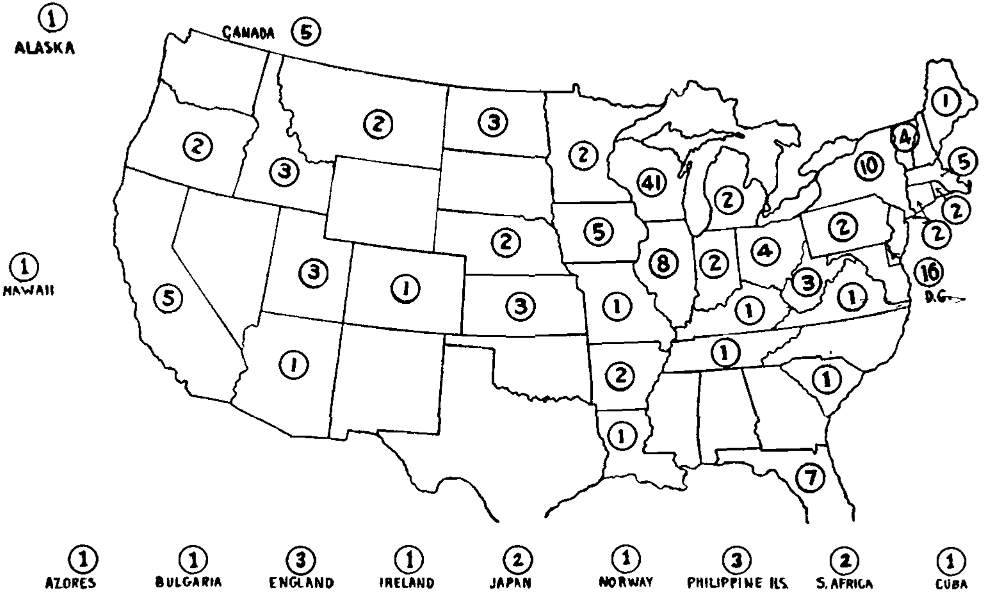
RAMIFICATIONS OF THE AGRICULTURAL COLLEGE



SOURCE AND LOCATION
MINNESOTA'S AGRICULTURAL POST-GRADUATES,
1906-1926.

THE LOCATION OF STUDENTS OF PROF. L. R. JONES, BY STATES

THE NUMBERS REFER TO THOSE WHO ARE ENGAGED IN PROFESSIONAL WORK IN BOTANY OR PLANT PATHOLOGY



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